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This secondary education student geography book contains chapters on climate, landforms, oceans, world vegetation, water resources, and population. Each chapter provides an introduction that describes the unit's topics, descriptive and instructional materials, learning activities, and questions. A glossary of geography-related terms and an eight-item bibliography are included, along with maps, charts, and drawings. (JHP)

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THE REALM OF PHYSICAL GEOGRAPHY

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TABLE OF CONTENTS

CHAPTER 1 Climate	pp. 1-46
Introduction	1
The Tilted Earth	2-5
Proofs of Sphericity	2-3
Actual Shape of the Earth	3
The Axial Tilt and it's Significance	3-4
Eratosthanese and the Calculation of the Earth's Circumference	4-5
Primary Movements of the Earth	6-11
Rotation	6-8
Proofs of Rotation	6-7
Effects of Rotation	7-8
Velocity of Rotation	8
Revolution	8-11
Proofs of Revolution	9-11
Velocity of Revolution	11
Climatic Influences	12-35
Latitude	12-17
Land and Water	18-26
General Circulation of the Atmosphere	20-22
Secondary Circulation	23-26
Monsoons	23-24
Land and Sea Breezes	24
Mountain and Valley Breezes	24-25
Chinook or Foehn Winds	25
Katabatic Winds	25
Santa Ana or Sirocco Winds	25-26
Ocean Currents	26-27
Altitude	27-28
Elevation	29-31
Air Masses	32-34
Storms	34-35
The Koppen Climatic Classification System	36-46
Tropical Rainy Climates	37
Dry Climates	38
Humid Mesothermal or Mild Temperate Rainy Climates	39
Humid Microthermal or Cold Snow Forest Climates	40
Polar Climates	41
The Practical Application of Koppen's System	42-46
CHAPTER 2 Landforms	47-81
Introduction	47
Characteristics of Landforms	48-49
Interior Structure of the Earth	50-54
Concentric Layers	52-54
Plate Tectonics	55-60
Relief Features of teh Earth	61-64
Ocean Basins	61-63
Continents	63-64

Volcanoes	pp. 65-71
Classification of Volcanoes	67-69
Location of Volcanoes	69-70
Earthquakes	72-78
Measurement of Earthquakes	73-76
Modified Mercalli Intensity Scale	75
Faults	76-77
Major Historic Earthquakes	77-78
Glaciers	79-81
Alpine Glaciation	79-80
Continental Glaciation	80-81
Piedmont Glaciation	81
CHAPTER 3 Oceans	82-102
Introduction	82
The Oceans of the World	83-84
Importance of the Oceans	85-86
Principle Movements of the Oceans anf their Causes	87-90
The Forces of Erosion and their Effect upon Shorelines	91-92
Major Shoreline Classification	93-97
Shoreline of Submergence	93-94
Shoreline of Emergence	94
Neutral Shoreline	94-97
Faulted Shoreline	97
Compound Shoreline	97
Features of the Oceans Basins	98-99
A Political Look at the Oceans	100-102
CHAPTER 4 World Vegetation	103-122
Introduction	103
Environments: Systems of Adaptation	104-112
Adaptation	106-108
Building Blocks of Adaptation	108-112
Climate	108-110
Soil	110-112
Vegetative Regions of the World	113-121
Forest Biome	113-118
Tropical Rainforest	113-114
Monsoon Forest	114
Temperate Rainforest	115-117
Mid-Latitude Deciduous Forest	117
Needleleaf Forest	117-118
Sclerophyll Forest	118
Grasslands Biome	119-120
Savanna	119
Prairie	119
Steppe	119-120
Desert Biome	120
Dry Desert	120
Semi-Desert	120

Tundra	pp.	120-121
Arctic Tundra		121
Alpine Tundra		121
Specific Terms Associated With Vegetation		122
CHAPTER 5 Water Resources		123-144
Introduction		123
Global Moisture System		124-131
Properties of Water		124-125
States of Water		125-127
Hydrologic Cycle		127-131
Fresh Surface Waters		132-140
Rivers		133-138
Physical Features Associated With River		136-137
The Chronological Development of Rivers and Streams		137-138
Ponds		139-140
Wetlands		140-142
Problems of Water Consumption		143-144
CHAPTER 6 Population		145-167
Living in the Bubble: An Introduction to World Population		145
Patterns of Population Growth		146-147
Population Density		147-149
Reasons for Areas of Dense Population		147-148
Reasons for Areas of Sparse Population		148-149
Statistical Approach in the Charting of Population Growth		150-153
Problems Associated With Overpopulation		153-156
Basic Reasons for Overpopulation		156-159
Global Attempts		159-162
Conclusions		162
Graphing Selected Statistical Date Pertaining to Population		163-164
Countries Within the Regions Graphed		165-167
GLOSSARY		168-180
INDEX		181-185
FOOTNOTES		186-187

AN INTRODUCTION TO CLIMATE

Relative to all factors influencing the various aspects of the earth's biological and physical environments, the elements of climate and the ever changing moods of our atmosphere dictate to us what our life style is going to encompass. Ranging from the tropical forests of the equatorial regions to the ice deserts of the poles, man's constant struggle to cope with and alter such environments to fit his needs has led us to a greater understanding of those agents determining climate. While exploring these agents, we will be covering such diverse topics as:

- The Tilted Earth
- Movements of the Earth
- Climatic Controls
- Koppen's Climatic Classifications

THE TILTED EARTH

'Proofs of the Earth's Sphericity'

Consider for one moment one of your close friends or associates coming up to you and aking, "How do you know the Earth is round?" Being convinced yourself of it's sphericity is one thing, but proving it to another is something else. For those who have relaxed on a beach and simply stared out at the endless expanse of an ocean, one answer to such a question should be easy to explain. Imagine watching a ship as it sails towards the horizon. Actually appearing to "sink" as it's voyage takes it beyond that imaginary plane where the earth and the sky appear to meet, the ship, in reality, is following the curvature of the earth. Such an illussion can be deceiving.

Very early voyagers quickly learned the value of charting the stars as they ventured out across the unknown oceans in search of new lands and wealth. For those sailing in the northern hemisphere, the discovery of the north star, Polaris, became a very valuable asset. What was observed was that the position of Polaris was the same degrees above the horizon as the degree designation of their northern latitude. For example, if your were to determine that Polaris was located 10 degrees above the horizon, that would mean your latitude was 10 degrees north. While standing on the equator, Polaris would be located on the horizon and at the North Pole, look directly overhead. The logical reasoning for such positioning has to be a curved surface, hence the Earth.

When the Earth, in it's orbit around the sun, gets directly between the sun and the moon, a shadow of the earth's surface creeps slowly across the lunar landscape. Known as a lunar eclipse, this simple observation convincingly shows the curvature of the Earth's surface.[1a]

One such proof which is not visual deals with an object located at sea level weighing the same on a spring type scale anywhere on the Earth as long as it is weighed

at sea level. If weight depends upon the pull of gravity, we can then conclude that all points of the Earth's surface which are of equal elevation are also equidistant from the Earth's center, hence a sphere.

For those who are still skeptical, the final and most convincing proof deals with actual photographs taken by astronauts from space and on the lunar surface. These striking and hauntingly beautiful pictures of our planet leave little doubt as to it's shape.

'Actual Shape of the Earth'

Having determined that the Earth is spherical, what geometric design, can we say, most closely resembles it? Due to the velocity of the Earth's rotation, the poles have a tendency to be flattened or drawn towards the center while the equatorial regions buldge. This specifically is refered to as an oblate ellipsoid. Proof of this is shown by the polar diameter measuring to be approximately 7,900 miles while the equatorial diameter is about 7,927 miles.

'The Axial Tilt and it's Significance'

The Earth is tilted on it's axis 23½ degrees away from a perpendicular. Upon close examination, before this statement can be fully understood, it must be broken down into it's component parts. To begin with, the axis is an imaginary line extending from pole to pole while passing through the center of the Earth around which the Earth does indeed rotate. The perpendicular refered to here is an imaginary line which is perpendicular to the plane of the ecliptic. Envision, if you will, a geometric plane passing through the center of the sun and extending outward through the entire solar system passing through the approximate centers of most of the planets with the exception of Pluto. The axial tilt is 23½ degrees away from this perpendicular and is the key determining factor in the distribution of sunlight across the face of the Earth.

When you first begin studying the physical make-up of the Earth, such important

latitudinal designations as the Tropics of Cancer and Capricorn along with the Arctic and Antarctic Circles probably come to mind. What you are generally not told, however, is their significance, or why they are located where they are.

With the equator being located directly between the North and South Poles, the importance of the Tropics of Cancer($23\frac{1}{2}$ degrees north) and Capricorn($23\frac{1}{2}$ degrees south) revolve around the fact that these are the farthest positions north and south of the equator the sun shines directly overhead. Refered to as the zenith position, the intensity of direct solar radiation is much more profound than those areas receiving slanted rays. This is why the tropical regions of the Earth are so collectively warm. The location of the tropics is solely determined by the axial tilt($23\frac{1}{2}$ degrees).

The significance of the Arctic and Antarctic Circles really explains a rather unique occurrence on the Earth. North of the Arctic Circle($66\frac{1}{2}$ degrees north) and south of the Antarctic Circle($66\frac{1}{2}$ degrees south), the Earth actually experiences complete periods of daylight and darkness. Sometimes known as the "land of the midnight sun", the reason for the location of the circles once again encompasses the axial tilt. It is between here and the poles the the Earth's coldest temperatures are generally recorded.

'Eratosthanese and the Calculation of the Earth's Circumference'

Before moving on to a discussion of the primary movements ou our planet, let's transport ourselves back in history 2000 years to a city in Egypt known as Alexandria. It was here at this city's fabulous library that it's chief librarian made his final calculations pertaining to the Earth's circumference. During one of his many travels, Eratosthanese happened upon an event in the city of Syene (presently called Aswan) which only happened once during the course of a year. On or about the date of June 21, a brilliant glare would radiate from the city's central well, so brilliant it was almost blinding. Caused by the vertical rays of the sun shining directly over

the well's floor, Eratosthenese took note of the sun's position to the Earth in relation to the horizon and determined it to be at an angle of 90 degrees above.

With this sticking in his mind, Eratosthaneses made his way back to Alexandria where he proceeded to calculate the sun's angle there on the exact same date. Estimating it to be 7.20 degrees lower at it's peak position and having a rudimentary knowledge of the mathematic discipline of geometry, the next logical step was to calculate what part of a circle 7.20 degrees of arc would be and then simply multiplying that by the distance between Alexandria and Syene. By dividing 360 degrees by 7.20, Eratosthanese found that to be 1/50 of a circle. With the distance between the two cities being 500 miles, the circumference of the Earth had to be approximately 25,000 miles. What makes this so remarkable is how close his calculations were in reference to the time in which it was determined.

PRIMARY MOVEMENTS OF THE EARTH

Ever since the ancients first gazed upon the heavens, it became very obvious that those bright objects which illuminated the evening darkness were not stationary. The stars were not only clustered into distinct patterns, they also appeared to move across the sky during the course of a night. So interesting were these observations, early astronomers and mathematicians began to ponder just how the Earth must fit into the overall scheme of the universe. Two early thoughts pertaining to this movement dominated the ideas of man well into the 18th century.

The geocentric theory, as developed by Ptolemy, proposed that the Earth was at the very center of the universe with all of the other heavenly objects revolving around it. While incorrect, it is easily understandable as to why such an idea would catch on. It wasn't until the 17th century that a man named Copernicus came up with a different thought. His heliocentric theory stated that the sun was near the center of the universe and that all other objects, including the Earth, revolved around it. Meeting much critisism, mainly from the clergy, it wasn't until men such as Galileo, Kepler, and Newton came on the scene that the Copernican theory was expounded upon. Still proving to be incorrect, Copernicus, at the very least, opened the door for future astronomers to come to grips with our Earth's movements (noteably, Johannes Kepler).

'Rotation'

Rotation is the spinning of the Earth around it's axis. The key term here is "around", because if you recall, the Earth's axis is imaginary. Caused by the gravitational attraction of the sun, rotation can be observed in four different manners with the most obvious being day and night. The sun shines on ½ of the Earth at any given time during the course of a day. As the Earth rotates, the distribution of sunlight changes. Part of the Earth will always be facing away from the sun, hence darkness.

The apparent motion of the sun and stars across the sky makes up the next two

observable proofs. Due to the west-east rotation of the Earth, these celestial objects appear to be moving in the exact opposite direction across our line of sight. While the sun's movement is very easy to track, constallations can also be observed by plotting their location just after sunset and just prior to sunrise.

The final proof of the Earth's rotation is really more physical. In the year 1852, Jean Foucault used a free swinging pendulum as a visual aid to prove this point. Having attatched a sharp stylus to the bottom of the pendulum, as the pendulum swung in an exact plane the stylus marked the smooth surface of a level sand pit it was swinging over. Over a period of time, the marks in the sand began to change direction, eventually returning to the original position. Since no outside force interfered with the plane of the pendulum, the only other logical explanation had to be the Earth rotating beneath it. A replica of Foucault's pendulum can be found in several museums around the world today.

'Effects of Rotation'

Many of the Earth's natural occurrences can directly or indirectly be traced to the rotational movement of the Earth. Imposing a daily rythm of certain phenomena to which plants and animals respond, the evolutionary process of adaptation, and the distribution of heat, humidity, and air flow all display concrete evidence of this. Unless sudden climatic changes occur, life forms generally adjust to their natural surroundings.

The tendancy for very small objects such as dust or water vapor to be "thrown" or pulled from the surface of the Earth due to it's rotational velocity is called centrifugal force. A close examination of tides is an excellant example of how this works. During the evening, as one side of the Earth faces the moon, the gravitational attraction from this orbiting satallite pulls the oceans waters into high tide. On the exact opposite side at the same time, high tides are also taking place except this time it is due to centrifugal force. Waters here are literally thrown into the high tide position.

Perhaps the most profound effect rotation has upon the Earth is a phenomena known as coriolus force. Simply stated, all freely moving objects are deflected to the right in the northern hemisphere and to the left in the southern downstream from their point of origin. This literally influences the directional flow of the winds and ocean currents unless some secondary force comes into play. A more detailed analysis of coriolus will be discussed in the section pertaining to climatic influences.

'Velocities of Rotation'

One of the most difficult concepts to envision when discussing the Earth's rotation has to do with it's differential rotational velocities. Keeping in mind, however, the shape of the Earth and the fact that it does make one complete turn around it's axis during the course of a 24 hour period will prove to be helpful. By using simple logic, it is easy to understand that parallels of latitude vary in circumference. Ranging from approximately 25,000 miles at the equator to a mere point on the Earth's surface at the poles, this spherical nature in conjunction with the fact that the entire body rotates at the same time gives rise to these variences. Let's examine this mathematically. Given the approximate circumference of the Earth at the equator and the time it takes to make one complete turn around it's axis, how fast does the Earth rotate at the equator? Upon the application of division, one can calculate the velocity to be in excess of 1000 miles per hour. Being that each parallel gets progressively smaller as you move towards the poles with the time element of rotation remaining the same, the velocity of the Earth's rotation thus diminishes.

Using this criteria in conjunction with what has previously been mentioned about rotation, how fast does the Earth rotate at the poles and why?

'Revolution'

The effect the gravitational attraction of the sun has upon all planets and satellites within our solar system also sets up another primary movement experienced not only by the Earth, but by all other members as well. This movement or orbit

of the Earth around the sun is known as revolution. As stated in Kepler's 1st Law of Planetary Motion, this orbit is of an elliptical nature moving across the ecliptical plane with the sun at one focal point of that ellipse. Simply stated, this orbit is not perfectly circular and the sun is not in the center.

Traveling in a counterclockwise direction around the sun, the Earth reaches it's farthest point in it's orbit on or near the date of July 4. At this time a distance of 94.5 million miles is reached. This position is refered to as aphelion which is from the Greek term meaning "far from the sun".

At it's closest encounter, perihelion, the Earth makes an approach of 91.5 million miles from the sun. The average Earth-sun distance of 93 million thus is the average between aphelion and perihelion.

'Proofs of Revolution'

The tilt of the Earth's axis in conjunction with it's location in it's orbit around the sun gives rise to the first solid proof of revolution being seasons. Seasons are determined by the vertical rays of the sun shining over particular areas of the Earth at certain times of the year. Upon the close examination of each, you will soon realize that opposite hemispheres experience opposite seasons at the same time. Before discussing each season individually, however, it is imperative that you understand certain concepts which are synonymous with these occurrences.

1. Seasons can begin as early as the 19th or as late as the 23rd of the said month. The 21st is an average date.

2. The term equinox refers to equal periods of daylight and darkness. With the sun rising in the true east and setting in the true west, the entire Earth experiences 12 hours of daylight and 12 hours of darkness.

3. The term solstice makes reference to the farthest positions north and south of the equator the sun shines directly overhead. As the sun appears to "stand still", this makes for the longest or shortest amount of daylight hours depending upon which hemisphere your in.

4. During the winter, the peak position of the sun is at it's lowest angle above the horizon (low sun period).

5. During the summer, the peak position if the sun is at it's highest angle above the horizon (high sun period).

When the vertical rays of the sun shine directly over the Tropic of Capricorn (23½ degrees south), the southern hemisphere begins it's season of summer while the northern begins winter. This occurs on or about the 21st day of December. During the Winter Solstice, nights become longer than daylight hours. This inequality increases poleward with the areas between the circles and the poles experiencing 24 hours or more of total darkness. The severity depends upon the areas latitude.

The Summer Solstice, on the other hand, experiences those conditions which are exactly opposite of winter. With the daylight hours now becoming longer, those areas between the circles and the poles now experience 24 hours or more of daylight.

As the Earth moves through the solar system on it's journey around the sun, it's next noticeable position occurs when the vertical rays of the sun are directly over the equator. Taking place twice during the year, on or about the dates of September 21 and March 21, the Autumnal and Vernal Equinoxes herald a transition period between the solstices of winter and summer. As the sun's rays strike the Earth, the circle of illumination (lines which divides the zone of daylight from the zone of darkness) passes directly through the poles, hence, 12 hours of daylight and 12 hours of darkness.

Lastly, as to it's farthest point north of the equator displaying a zenith position, the vertical rays of the sun shine directly over the Tropic of Cancer (23½ degrees north). This is the beginning of summer in the northern hemisphere and winter in the south occurring on or about the date of June 21 each year.

The other proof dealing specifically with the Earth's rotation has an origin which is astronomical. The concept is known as stellar parallax and has to do with the small angular shift in a stars apparent motion. The best way to explain this is by placing a mark or an object on a wall or chalkboard. Step back several feet, close one eye and cover the object by placing your thumb between it and your line of sight. Now open the closed eye and close the other. What happened? Obviously the object did not move, but your line of vision did.

Astronomers looked for years for certain stars which would "line up" with the Earth so this concept could be tested. It wasn't until 1837 that an astronomer named F. G. W. Struve discovered this phenomena and the second solid proof of the Earth's revolution came about.

'Velocity of the Earth's Revolution'

Kepler's 2nd law of planetary motion states that all planets within our solar system sweep equal arcs over squal periods of time. In other words, they are all traveling at the same speed. The variences take place at the planets closest approach which is perihelion, and at the farthest position, aphelion.

The length of time it takes for the planets to orbit the sun is called a year and is directly related to their distance from it. For example, it takes the planet Mercury only 88 Earth days to make one complete orbit around the sun. A year on Mercury then is only 88 days long. Pluto is an entirely different story. Being that Pluto is such a long distance from the sun, it takes it 248 Earth years to make one complete and very erratic orbit. One year on Pluto is then equal to 248 of ours.

Being that time has always been a very important factor to all of us, it stands to reason that the velocity of the Earth on it's journey through space would be measured. Caused directly by the sun's gravitational attraction, the Earth is hurled and pulled through space along the ecliptical plane at an average speed of 18.5 miles per second. With this in mind, the following chart relates the time-distance concept of the Earth and it's orbit.

Time	Distance
1 second	18.5 miles
1 minute	1,110 miles
1 hour	66,600 miles
1 day	1,598,400 miles
1 year	583, 815, 600 miles

CLIMATIC CONTROLS

A topic which seems to make it's presence known in some manner every day, be it through the media of radio, television, or the newspaper, is weather. Defined as the daily conditions of the atmosphere, weather plays such a dominant role in our existance that we pattern our lifestyle, and to a large extent our daily activities, around it. As we look at the overall pattern weather commands, and the affect it has upon particular areas of the world, we begin to feel a sense of awe as these forces of nature come together creating spectacular and sometimes eventful conditions. Climate is the result of these conditions as judged over a long period of time. The purpose of this section is to familiarize you with climate and the controls which either individually or collectively determine the environments in which we live.

'Latitude'

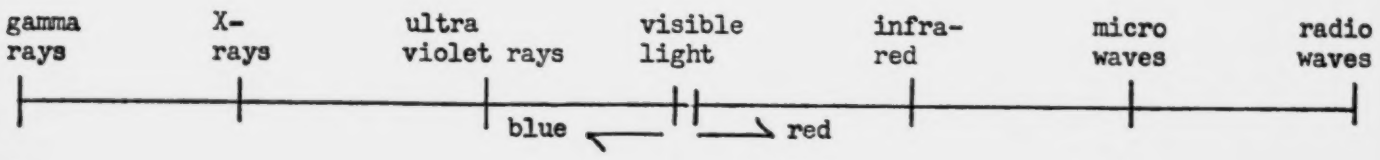
As alluded to earlier, those areas of the Earth which receive the vertical rays of the sun experience a greater amount of solar intensity than those receiving angular rays. Specifically refered to as insolation, this amount of radient energy obtained from the sun on the horizontal surface of the Earth can best be observed by focusing in on the distribution of our global energy. This inequality become quite obvious by the differences in temperature recorded from the tropics all the way to the poles. Heat is first received by the atmosphere, transfered to land and water surfaces, and eventually returned to the atmosphere. Coming to us in the form of light, solar radiation is broken down according to it's intensity. The light which is visible actually makes up a very small amount in relation to what is dispersed across the electromagnetic spectrum. Radiation comes to us in the form of high frequency (short wave length) and low frequency (long wave length) waves. On the "blue" end of the spectrum, high frequency waves such as ultra violet, X-rays, and gamma radiation are found. Being extremely harmful to all life forms, our planet is blanketed by a layer of ozone which is responsible for scattering most of these short waves, thus protecting us. This is also why the sky is blue.

The Earth today, however, is experiencing a very elemental threat which is basically man induced and has perhaps the most far reaching consequences ever imposed upon the human race. Through the excessive use of floro-carbons, and the exhausts from automobiles and industry, this vital layer of ozone is being destroyed. In tracing the movement of pollutants through the global circulation of air, scientists have been able to hone in on certain areas of the Earth which are showing the most signs of distress. Antarctica is one such area. With a great amount of intensity, scientists are looking towards the weakness of the ozone here as a possible cause for the excessive melting of the South Polar icecap. As a result of this, sea level around the world is rising at a much faster rate than what has been considered normal.

On the other end of the spectrum, in which radiation levels are of low frequency, wave lengths of infra-red, micro waves and radio waves are dispersed. This "red" portion consists of radiation which is not as harmful.

With the sun being almost the sole source of the Earth's energy, let's analyze how this energy is distributed as it reaches our planet. As a relatively close member of the solar system, the Earth receives approximately ½ of the amount of light released by the sun. Of this energy, 37% is reflected back out into space by the Ozone Layer, 20% is absorbed into the atmosphere by dust particles and water vapor, and 43% is taken in by the Earth's surface. Upon reaching the surface, that short wave length radiation which does break through is converted into long wave length ground radiation when it returns to the atmosphere.

ELRCTROMAGNETIC SPECTRUM



To develop a better understanding of what has just been discussed, let's use some simple mathematic calculations to determine the angle of the sun at it's peak position above the horizon. Initially certain facts must be obtained either through the use of an anelema (a special chart indicating the sun's zenith position on any given date) or by a statement of that neccessary information. While an anelema is very useful and simply understood, for convenience we will make use of the following chart indicating seasons in the northern hemisphere, beginning dates, and the sun's zenith position on those dates.

SEASON	DATE *	SUN'S ZENITH POSITION
Autumnal Equinox	September 21	Equator-0° latitude
Winter Solstice	December 21	Tropic Of Capricorn-23½° N
Vernal Equinox	March 21	Equator-0° latitude
Summer Solstice	June 21	Tropic of Cancer-23½° N

*A season can begin as early as the 19th or as late as the 23rd of said month. The beginning date depends upon when the sun's vertical rays are positioned directly above the tropics or the equator. The 21st is an average date.

A basic question will be asked for every problem pertaining to sun angle:

"How far above the horizon will the noon sun travel on (date) at (location)?"

We will seek the solution to this question by using the above chart to obtain the neccessary dates and locations. The following steps will be used:

1. Determine the location of the sun's zenith position on the given date.
2. Determine the latitudinal location of the area in question.
3. Determine the difference in degree distance between numbers 1&2. This also tells you how far below the sun's zenith position the sun is in the area in question.
4. Subtract the answer obtained from step #3 from the sun's zenith angle which is 90°.
5. Always write "above" or "below" the horizon behind the final answer, whichever is applicable.

Problem # 1

How far above the horizon will the noon sun travel on September 21 at the Tropic of Cancer?

Step 1 Sept. 21- Sun is at a zenith position over the equator- 0° latitude.

Step 2 Tropic of Cancer latitudinal location- $23\frac{1}{2}^\circ$ N

Step 3 $23\frac{1}{2}^\circ$ N
$-\ 0^\circ$
$23\frac{1}{2}^\circ$ difference in degree distance between the two locations

Step 4 90° zenith angle
$-23\frac{1}{2}^\circ$ result of step 3

Step 5 $66\frac{1}{2}^\circ$ above the horizon

Problem # 2

How far above the horizon will the noon sun travel on December 21 at the Tropic of Cancer?

Step 1 December 21 sun is at a zenith position over the Tropic of Capricorn $23\frac{1}{2}^\circ$ S

Step 2 Tropic of Cancer latitudinal location- $23\frac{1}{2}^\circ$ N

Step 3 $23\frac{1}{2}^\circ$ N
$+23\frac{1}{2}^\circ$ S
47° difference in degree distance between the 2 locations

Step 4 90° zenith angle
-47° result of step 3

Step 5 43° above the horizon

Problem # 3

How far above the horizon will the noon sun travel on March 21 at the Tropic of Cancer?

Step 1 March 21 sun is at a zenith position over the equator 0° latitude

Step 2 Tropic of Cancer latitudinal location- $23\frac{1}{2}^\circ$ N

Step 3 $23\frac{1}{2}^\circ$ N
$-\ 0^\circ$
$23\frac{1}{2}^\circ$ difference in degree distance between the two locations

Step 4 90° zenith angle
$-23\frac{1}{2}^\circ$ result of step 3

Step 5 $66\frac{1}{2}^\circ$ above the horizon

Problem # 4

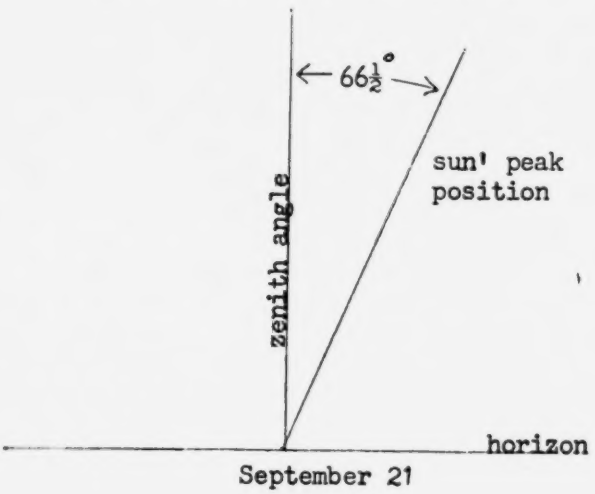
How far above the horizon will the noon sun travel on June 21 at the Tropic of Cancer?

Step 1 June 21 — sun is at a zenith position over the Tropic of Cancer- $23\frac{1}{2}^\circ$ N

Step 2 Tropic of Cancer — latitudinal location- $23\frac{1}{2}^\circ$ N

Step 3
$23\frac{1}{2}^\circ$ N
$-23\frac{1}{2}^\circ$ N
0° difference in degree distance between the two locations

Step 4 90° zenith angle
$-\ 0^\circ$ result of step 3
Step 5 90° above the horizon



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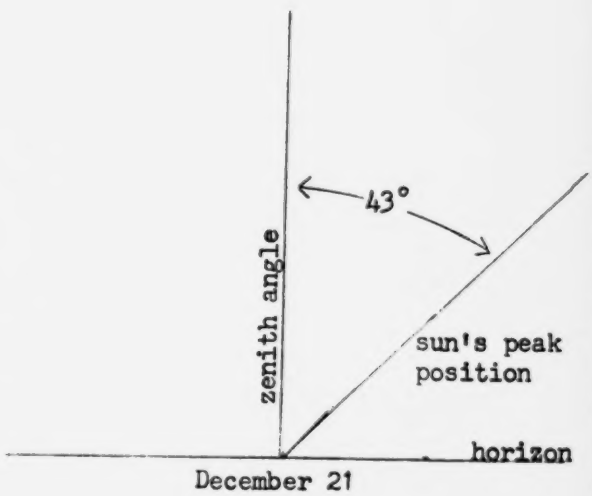

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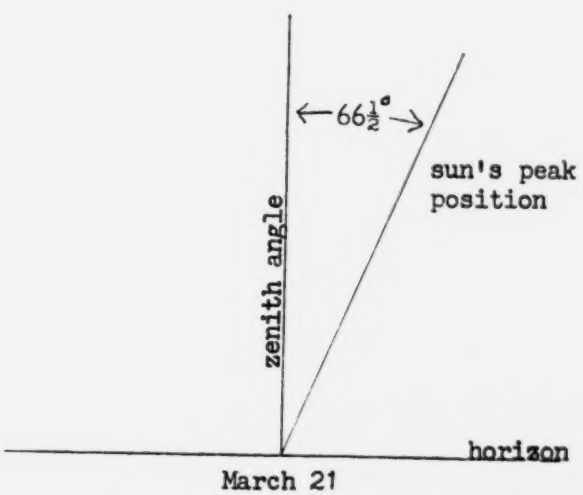

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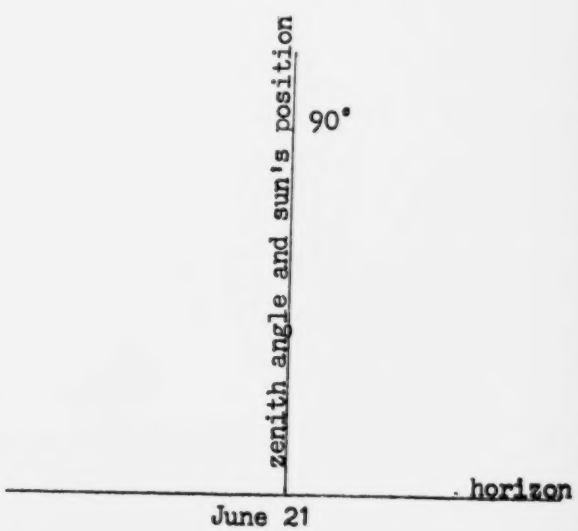

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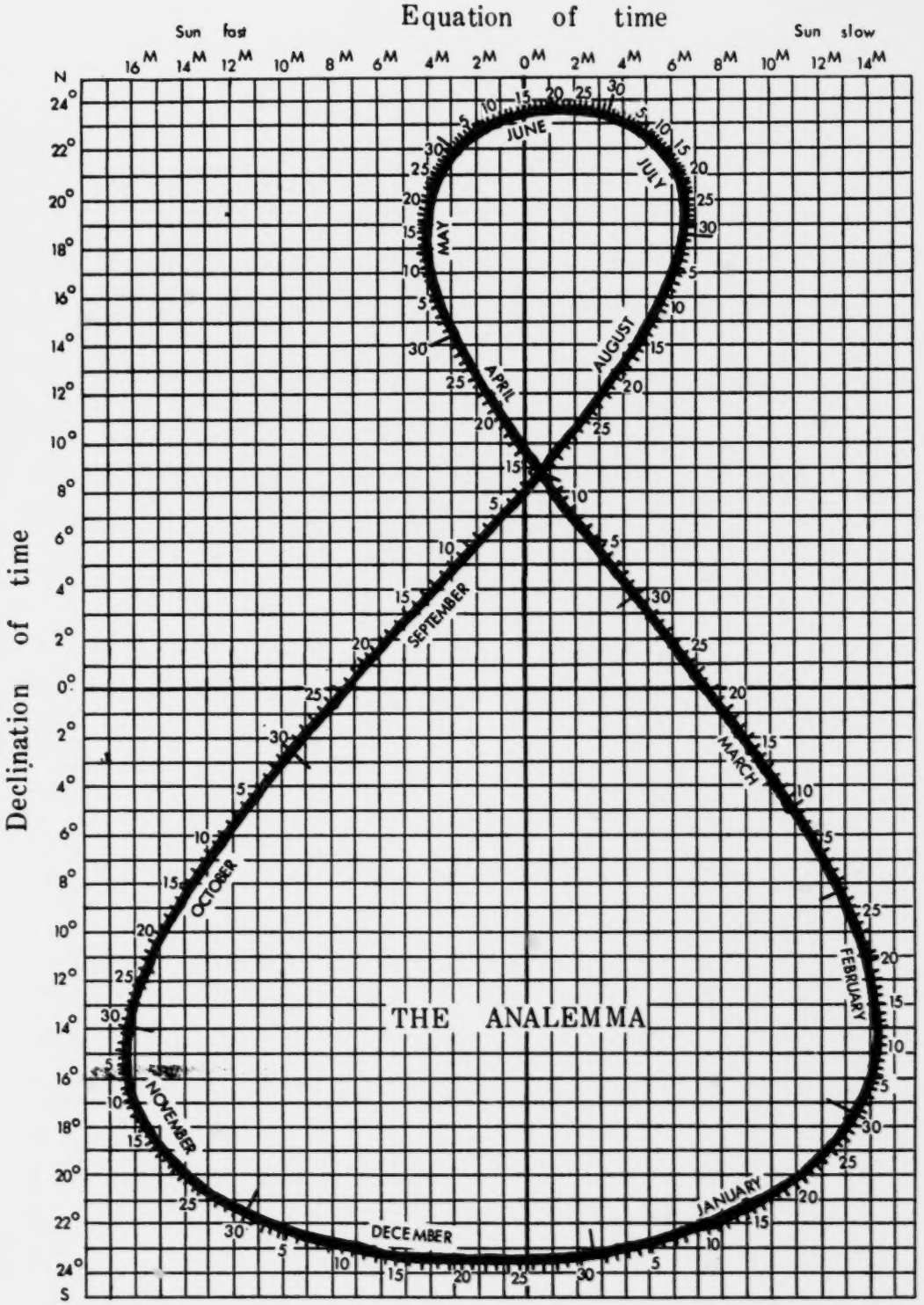

Equation of time
Sun fast
Sun slow
16M 14M 12M 10M 8M 6M 4M 2M 0M 2M 4M 6M 8M 10M 12M 14M
Declination of time
N
24° 22° 20° 18° 16° 14° 12° 10° 8° 6° 4° 2° 0° 2° 4° 6° 8° 10° 12° 14° 16° 18° 20° 22° 24°
S
JUNE
JULY
AUGUST
MAY
APRIL
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
THE ANALEMMA

25h

'Land and Water'

Before discussing what influences land and water has upon certain areas, a few facts must be brought forward and learned for future reference.

1. Warm air rises and expands. If you have ever seen the preparation and take-off of a hot air balloon, this process is quite apparent. Large fans are used to push the initial thrust of air into the balloon, "blowing it up". What is very obvious, however, is the fact that the balloon is not yet in an upright position. This will not happen until heat is introduced. With large burners, the air is warmed thus forcing it to a vertical stance. As more heat is added, the sides of the balloon begin to expand and eventually rises off of the ground. What this proves is that warm air is lighter than the cooler air around it.

2. Cool air settles and contracts. During the summer, as the temperatures soar, the coolest place in a house with a basement, is the basement. This is primarily due to the fact that the cooler air in the upper portions of the house eventually makes it's way to the basement. Cooler air is thus heavier than the surrounding warmer air.

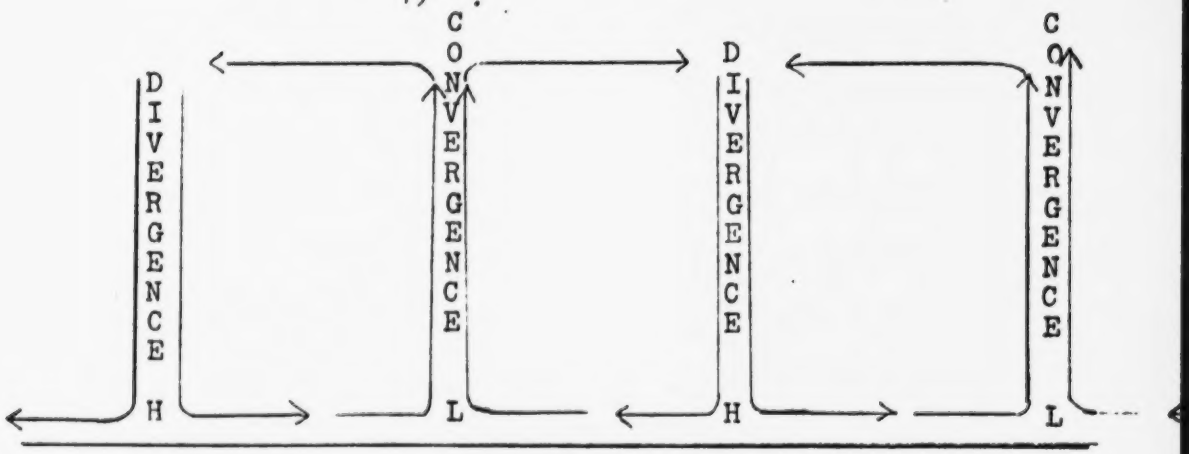
3. Land heats up and cools off faster than water. This concept is really very easy to understand if you consider the physical make up of each body. Water, under normal circumstances, is a transparent liquid which allows sunlight to penetrate well beyond just the surface. The sun's radient energy is thus heating a greater volume which takes longer. In like manner, it takes longer to cool off.

   Land, on the other hand, is a solid. Sunlight directly affects only the surface area, decreasing the amount of time it takes to heat up and cool down. The direct result of this temperature imbalance is air movement, or wind.

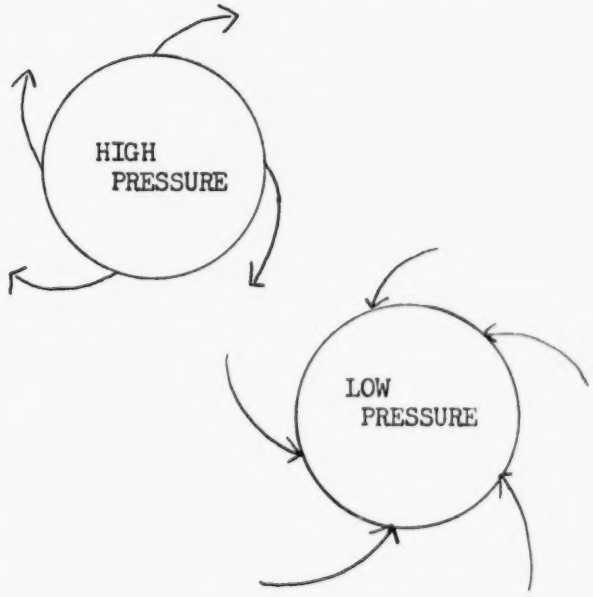
4. In reference to pressure cells, air always flows out of a high pressure cell and into a low pressure cell. As the name indicates, areas of high pressure consists of air which is heavier. This sinking or settling air gets warmer as it reaches the surface diverging outward in a clockwise direction in the Northern Hemisphere and counterclockwise in the Southern. The directional flow is caused by the coriolus force of the Earth's rotation. Skies in and around an area of high pressure are clear which indicates dry weather.

   Low pressure consists of air which is in a constant state of rising. Refered to as an area of convergence, warmer air coming from areas of divergence (the warming trend of settling air as it reaches the surface of the Earth) meet and rise up into the atmosphere. As the air rises, it cools beyond it's dew point,(that critical temperature beyond which moisture condenses) thus condensing and forming clouds. Low pressure is associated with cloudy skies and chances of precipitation.

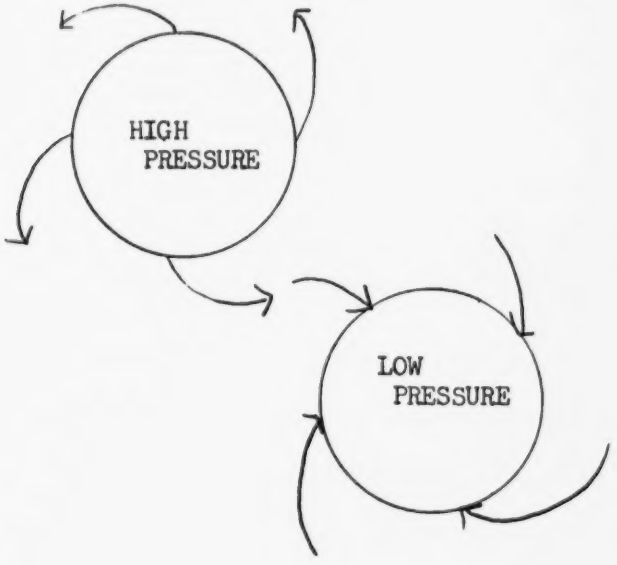
   Once again, the directional flow of air into a low pressure cell depends upon coriolus. Counterclockwise circulation into the low pressure occurs in the Northern Hemisphere while clockwise circulation occurs in the Southern.



* AIR CLOSE TO THE SURFACE FLOWS IN AN OPPOSITE DIRECTION TO THE AIR ALOFT



NORTHERN HEMISPHERE



SOUTHERN HEMISPHERE

"General Circulation of the Atmosphere"

Taking into consideration the facts just mentioned, let's examine where pressure cells develop around the Earth and what affect they have upon those locations.

Beginning with that area which experiences the most direct rays of the sun, an intense low pressure system known as the Equatorial Doldrums * develops between 2 and 3 degrees north and south of the equator. Exhibiting some of the warmest seasonal temperatures anywhere, this warm air is in a constant state of rising, thus frequently developing heavy convectional thunderstorms lasting at the most ½ hour in length. With almost no horizontal movement of air, the weather becomes very predictable and monotonous.

Located between 0 and 30 degrees north and south of the equator, an area known as the Trade Winds exists. Keeping in mind that winds are named for the direction in which they originate, north of the equator these winds are known as the Northeast Trades and south of the equator, the Southeast Trades. Resulting from air which converges at oblique angles in the doldrum zone, these light steady winds create very favorable climatic conditions in those areas which would otherwise be entirely too warm. Using the Hawaiian Islands as examples, The "trades" keep the average high temperature from exceeding 89 degrees F and the average low above 58 degrees F.°

*As a side note, these winds obtained their name from the early sailors which used them as a major means of powering their vessels as they made the many trips to the "new world" in search of new trade markets and wealth. What you have to remember is that these sailors were completely at the mercy of the winds and the ocean currents to move their ships.

The Sub-Tropical High Pressure Belt or otherwise known as the Horse Latitudes, is located 30 degrees north and south of the equator. As the name implies, immense areas of high pressure emminate from these parallels setting up those climatic conditions which are condusive to the development of deserts. As a matter of fact, most of the worlds deserts are located here. Being a zone of divergence, very calm winds are part of the norm. The name "Horse Latitudes" stems from the legend that as early

*Technically known as the Intertropical Zone of Convergence

explorers (Spanish mainly) got caught up in these calm waters, their vessels floated helplessly due to the absence of wind. Faced with some very dire circumstances, they simply pushed the horses overboard in order to lighten the load.

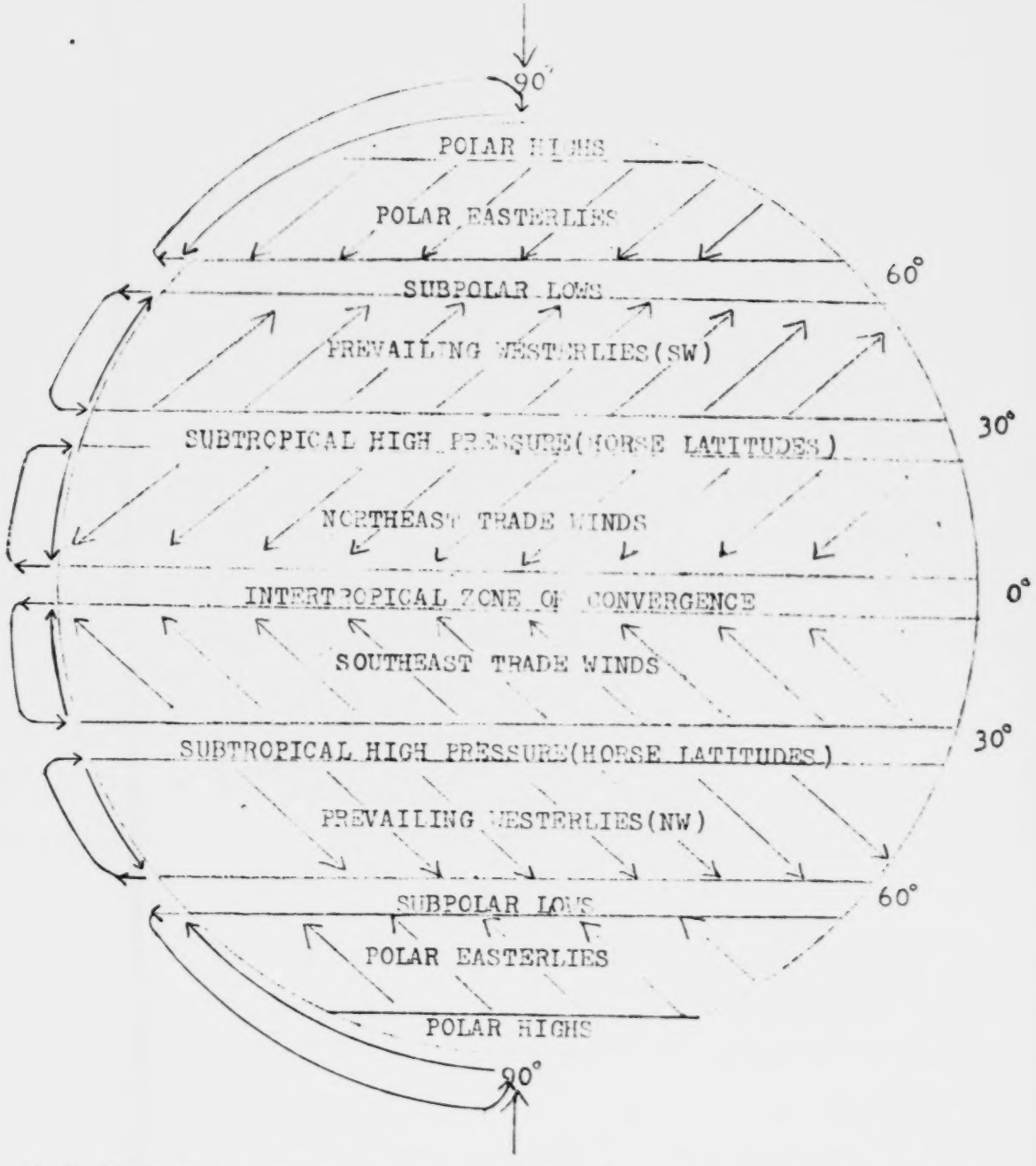
Progressing poleward, the next area of recognition is the Prevailing Westerlies. Located between 30 and 60 degrees north and south of the equator, these middle latitude winds blow from the west to the east in a very erratic manner. Due to the absence of large land masses in the southern hemisphere, these winds go almost unhindered creating extremely hazardous conditions around the southern tip of South America at times. Winds coming off of the Andes Mountains are thrown around the "horn" of South America compressed into what is like a tunnel. Traveling through the Strait of Magellan is somewhat safer, but still dangerous. With the winds being stronger in the winter, people living in these latitudes need only look west to see what impending weather is coming their way.

The Sub- Polar Lows are found on and around around the 60th parallel north and south. As a zone of convergence, this region of low pressure gives rise to cloudy skies, bringing with it rain or snow.

The Polar Easterlies are known for their very strong, bitterly cold winds occurring especially in the winter. Emminating from the polar regions of the world, between 60 and 90 degrees north and south of the equator, these winds sometimes make their presence known below this region affecting those lands tremendously.

Last, but surely not least, is the Polar High Pressure Center, located over each pole. As an area of divergence, extremely dry conditions prevail here, in essence creating desert conditions. The frigid air of the Polar Easterlies originate here.

GENERAL CIRCULATION OF THE ATMOSPHERE



* Air aloft flows in the exact opposite direction as the air near the Earth's surface

"Secondary Atmospheric Circulation"

In a few instances, local climatic and atmospheric conditions will override the Earth's general air circulation. Refered to as Secondary Circulation, these winds are the direct result of temperature differences, either seasonal or daily, which vary in intensity and area. We will examine six such patterns thus enabling you to directly observe these variations.

Monsoons

A major misconception seem to occur when the word "monsoon" is mentioned. Most associate this with torrential downpours of rain predominantly found in perpetually wet climates. In reality, however, a monsoon refers to a seasonal wind created by the seasonal reversal of pressure cells over a given area. Mainly originating over the tropical regions of the Earth, these winds are the direct result of the intense solar radiation experienced here and the affect it has upon large masses of land (continents) and water (oceans).

During the monsoonal summer of the northern hemisphere (May-October), the sun bears down relentlessly over the large land masses heating them in what seems to be an endless fashion. The land in turn directly heats the air above causing it to rise and expand at a steady rate. This process is known as terrestrial radiation and the overwhelming result is an intense area of low pressure.

Out over the oceans, where the water temperatures are considerably cooler, an area of divergence or high pressure develops. Think back, if you will, to the explanation centering around the movement of air out of a high pressure cell and into a low. Moving clockwise out of the high, air passes over large bodies of ocean water evaporating and carrying large quantities in a gaseous form inland as it travels towards the low pressure cell. Bringing this moisture inland sets up excellant conditions condusive to the development of rain. Being this process continues for almost 6 months, precipitation continues on a regular basis until the winds change.

As the year progresses, temperatures change, thus affecting the pressure cells.

During the monsoonal winter (October- May), most of the regions heat is now originating over the oceans. Being that water holds it's heat longer than land due to it's transparency, larger amounts of air are now rising off of the oceans developing intense systems of low pressure. High pressure is now located over the land masses thus fully reversing themselves. As the air flows across the land, dry winds bring many months of harsh weather and hard times to the people whose very existance is centered around this climatic pattern.

Land and Sea Breezes

On the coastal regions of the world, a diurnal (daily) wind pattern develops as a result of the fluxuation of temperatures existing between land and water. During the day, as land heats at a greater rate than water, air rises steadily setting up a pattern of air movement. Cooler air from over the sea comes inland replacing the rising and expanding air from over the land. As the air aloft cools, it settles over the sea creating a sea to land cycle known as a sea breeze during the day.

Upon the approach of late afternoon, temperature differences between land and water are basically non-existant creating calm conditions. However, as evening settles in, land areas begin to loose their heat at a more rapid rate. With more rising from over the sea, that air from the land moves outward to replace it. Once again, air aloft cools and settles, but this time over land thus completing this land to sea cycle dring the evening known as a land breeze.

Mountain and Valley Breezes

Another diurnal wind pattern which exists in the mountainous areas of a continent is the mountain and valley breeze. During the day, as mountain slopes heat at a much greater rate than the adjacent valleys, a large amount of warm air rises to the higher elevations thus having to be replaced by the cooler valley air. As the rising and expanding air from the mountain slopes gain altitude, it cools and begins to settle back to the valley floor. The duration of this valley breeze during the day

depends upon inclament weather conditions, and of course, the time of year in many cases.

As evening approaches, the temperatures in the upper elevations of the mountains drop rapidly. A greater amount of valley air is now rising and being replaced by the descending air from the slopes. Air aloft cools and settles completing this integral part of the mountain breeze.

Chinook or Foehn Winds

A downslope flow of air on the leeward side of muntain ranges in the middle latitudes gives rise to what are known as chinook winds. Occurring during the winter months, this warm, dry flow of air has been known to warm the temperature of a region as much as 40 degrees within a few hours. As a result, much static electricity develops. On the North American continent, primarily along the east coast of the Rocky Mountains, these winds are well known. In Europe around the Swiss Alps, these are known as foehn winds.

Katabatic Winds

The drainage of very cold dense air down the slopes of high plateaus or the glacial fields of Greenland and Antarctica give rise to katabatic winds. Know to be very cold, these winds thrive in winter conditions in which temperatures plunge to a -7- to -80 degrees F.

Santa Ana or Sirocco Winds

Originating in areas where warm continental tropical air masses develop, hot dry winds blowing from adjacent desert areas present themselves in the late summer or early fall. Having the possibility of lasting several days, these relentless winds cause brush fires and make life generally miserable for almost all life forms involved. Known as the sirocco winds in the Middle East, the countries of Israel and Lebanon receive them from the Arabian Desert while the Santa Ana's of North America originate over northern Mexico.

As a final note, lands adjacent to large bodies of water generally have more moderate climates than those located much further inland. The centers of large continents such as Asia or North America are noted for greater temperature extremes over the course of a year and are subjected to more severe winters and summers. This coupled with latitude can create some very unpredictable weather conditions.

'Ocean Currents'

To fully comprehend the effect ocean currents have upon the lands they flow by, one must understand the origins of these currents and the cause of their directional flow. If allowed to flow unimpeded by any large mass of land, ocean currents will move clockwise in the northern hemisphere and counterclockwise in the southern due to the rotational affect of coriolus. Through the heat transference of convection, heat is moved from one place to another bringing colder or warmer temperatures into areas which would otherwise not experience such a change.

Upon close examination, ocean currents can be classified according to temperature and strength. Those originating in the Earth's Polar regions and flowing towards the tropics are classified as cold currents due to their movement of colder water. Lands adjacent to them are generally cooler and drier in comparison to those influenced by warm currents.

Warm currents originate in the Earth's tropical zones and flow poleward bringing with them warm waters. The effect such currents have upon lands can be observed by looking at the west coast of Norway. According to it's latitude, winter temperatures should be low enough to cause the waters of the Atlantic Ocean to freeze. The approach of warm waters from the Gulf Stream, the North Atlantic Drift, and the Norwegian Current prevent this from happening. Lands adjacent to these currents are generally warmer and more moist in comparison to those next to cold currents.

In brief reference to strength, currents are classified as streams (the stongest) currents, and drifts (the weakest). The velocity of each current depends upon the

shape of the ocean's Continental Margin and Floor over which it flows along with the presence of landmasses which will slow it's progress.

As should be evident, ocean currents in conjunction with prevailing winds have a definite influence upon weather patterns of the lands next to them. Natures schematic patterns continue to work.

'Altitude'

The fourth aspect of climatic controls specifically involves the relationship of altitude (height above a given surface) with temperature. You have no doubt noticed that the tops of tall mountains have a tendency to remain snow covered throughout the entire year regardless of the location. From this we can conclude that there is a direct corolation between the increase in altitude and the decrease in temperature. This is true up to that part of the atmosphere known as the ozone layer where extremely harmful high frequency radiation from the sun is scattered, thus causing temperatures to increase.

The methods in which temperatures are measured in the upper altitudes revolve mainly around one key climatic element, that of wind. In the absence of air movement, the Normal Lapse Rate is used to calculate this steady drop in temperature. Simply stated, when atmospheric conditions are calm, air temperature drops at a rate of 3.5 F for every 1,000 foot increase in altitude. When given a specific surface temperature to begin with, calculations can be made as to what the temperature would be at any given level. Let's see how this works.

We'll start off with a basic statement of the problem:
"Given a surface temperature of 70° F, use the Normal Lapse Rate in calculating the air temperatures at the following altitudes:

a. 3,500' _____
b. 6,000' _____
c. 10,500' _____
d. 13,250' _____

In order to solve the above problems, certain steps must be followed to insure the proper results.

1. Determine the number of 1,000' intervals between the surface and the altitude in question.

2. Multiply that number by the Normal Lapse Rate (3.5°).

3. Subtract the result of step #2 from the given surface temperature.

Problem "a":

3.5 = the number of 1,000' intervals in 3,500' (step 1)
3.5° F = the Normal Lapse Rate

3.5 x 3.5° F = 12.25° F - the temperature difference between the surface and 3,500' (step 2)

70.00° F - 12.25° F = 57.75° F - the temperature at 3,500' (step 3)

Problem "b"

6 = the number of 1,000' intervals in 6,000 ' (step 1)
3.5°F = the Normal Lapse Rate

6 x 3.5°= 21°F - the temperature difference between the surface and 6,000' (step 2)

70°F - 21° F = 49° F -the temperature at 6,000' (step 3)

Problem "c"

10.5 = the number of 1,000' intervals in 10,500' (step 1)
3.5° F = the Normal Lapse Rate

10.5 x 3.5° F = 36.75° F - the temperature difference between the surface and 10,500 ' (step 2)

70.00°F - 36.75° F = 33.25° F - the temperature at 10,500' (step 3)

Problem "d"

13.25 = the number of 1,000' intervals in 13,250' (step 1)
3.5° F = the Normal Lapse Rate

13.25 x 3.5° F = 46.375° F - the temperature difference between the surface and 13,250'

70.000°F - 46.375° F = 23.625° F - the temperature at 13,250' (step 3)

'Elevation'

Not totally leaving the concept of height, we can now look towards the presence of elevation and the influence it has upon climate as opposed to altitude as our next area of interest. The basic premise involving a temperature drop with an increase in elevation still holds true, but the method in which it is calculated is different. Instead of the atmospheric conditions being calm as they were when the Normal Lapse Rate was used, winds are now present thus changing the whole composition of air temperatures.

Before we get into that, let's look at what elevation basically consists of and how it differs from that of altitude. Whereas altitude is height measured above any given surface, elevation is the height above and below the datum plane of sea level. A change in elevation can be gradual, as it is when one approaches the Rocky Mountains from the east, or rather abrupt, as is the case at the base of certain mountain systems. Regardless of the circumstances, as wind confronts either situation, it is forced to rise very systematically. As the air rises, it cools adiabatically eventually reaching the point where the moisture within condenses and forms clouds. This adiabatic cooling of the air is what we want to examine as it applies to the calculation of the actual air temperatures.

Before moisture condenses, air temperatures are determined by using the Dry Adiabatic Rate of Cooling. This states that as air is being forced upward, it is cooled at a rate of 5.5° F/ 1000' increase in elevation.

As the dew point is reached and condensation occurs, this rapid descent of temperature is slowed up by what is called the latent heat of condensation. When water does condense, a very small amount of heat, which has been stored up in its gaseous form, is released. The result is exhibited in the Wet Adiabatic Rate of Cooling which states that air temperature here drops at a rate of 3.2° F/ 1000' increase in elevation.

To fully understand how this works, the following working diagram has been

supplied for your convenience. Note that the upper and lower levels of condensation have been identified as the cloud is situated along the slope of the mountain. The temperature at the base of the windward side is up to your discretion, but we'll walk through one such problem to help you become aquainted with the procedure.

* Statement of the problem:

"Using the accompanying diagram along with the Wet and Dry Adiabatic Rates of Cooling, calculate the air temperatures at 4,500', 7,000', 12,750', and at the base of the leeward side of the mountain when the temperature at the base of the windward side is 70 ° F.

*Procedure used in solving problems:

1. Determine the number of 1000' intervals between the two elevations in question.

2. Determine which adiabatic rate of cooling would be applicable in this specific situation.
   ** Note- the Wet Adiabatic Rate of Cooling is used only in the presence of condensation.

3. Multiply the adiabatic rate determined from step 2 by the number of 1000' intervals dtermined from step 1.

4. Subtract the result obtained from step 3 from the last known temperature.

*Working the problem:

1. temperature at 4,000'

   a. the number of 1,000' intervals between 0' and 4,000' is 4 (step 1)

   b. between sea level and 4,000' there is no condensation occurring so the Dry Adiabatic Rate of Cooling is used. 5.5° F/1000' increase in elevation. (step 2)

   c. 5.5° F x 4 = 22° F -the temperature difference between sea level and 4,000' (step 3)

   d. 70° F - 22° F = 48° F -the temperature at 4,000' (step 4)

2. temperature at 7,500'

   a. the number of 1000' intervals between 4,000' and 7,500' is 3.5 (step 1)

   b. between 4,000' and 7,500', clouds are present so the Wet Adiabatic Rate of Cooling is used. 3.2° F/1000 ' increase in elevation (step 2)

   c. 3.2 x 3.5 = 11.2° F -temperature difference between 4,000' and 7,500' (step 3)

   d. 48° F - 11.2° F = 36.8° F - temperature at 7,500' (step 4)

3. temperature at 12,750'

   a. the number of 1000' intervals between 7,500' and 12,750 feet is 5.25 (step 1)

   b. between 7,500' and 12,750 ' there is no condensation present so the Dry Adiabatic Rate of Cooling is used. 5.5° F/1000' increase in elevation (step 2)

   c. 5.25 x 5.5 = 29.875 ° F -temperature difference between 7,500' and 12,750' (step 3)

   d. 36.8 °F - 29.875 ° F = 6.925 ° F- temperature at 12,750' (step 4)

4. temperature at the base of the leeward side of the mountain

   a. the number of 1000' intervals between 12,750' and the base of the leeward side of the mountain is 12.75. (step 1)

   b. between 12,750' and the base of the leeward side of the mountain there is no condensation present so the Dry Adiabatic Rate of Cooling is used. 5.5 ° F/ 1000' increase in elevation (step 2)
   ** Note- in this case, instead of subtracting in the final step, you must add because you are descending

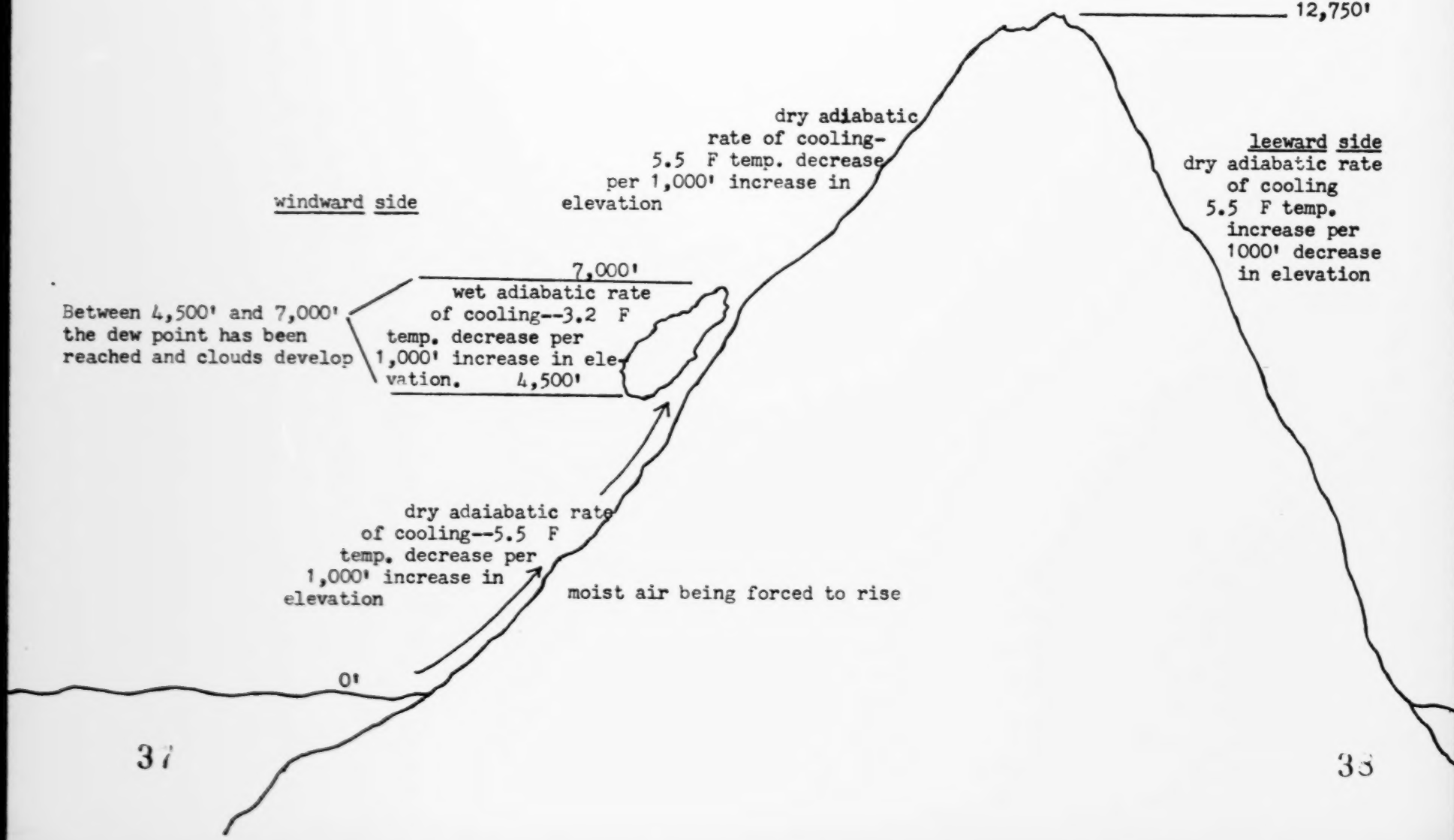
   c. 12.75 x 5.5 = 70.125 ° F -temperature difference between 12,750' and the base of the leeward side of the mountain (step 3)

   d. 6.925 ° F + 70.125 ° F = 77.050° F -temperature at the base of the leeward side of the mountain. (step 4)

   * The reason for the temperature increase on the leeward side of the mountain is because there are no clouds to slow up the temperature change.

1. dry adiabatic rate of cooling is used only in the absence of condensation.

2. wet adiabatic rate of cooling is used only in the presence of condensation.


12,750'
dry adiabatic rate of cooling- 5.5 F temp. decrease per 1,000' increase in elevation
windward side
leeward side
dry adiabatic rate of cooling 5.5 F temp. increase per 1000' decrease in elevation
7,000'
wet adiabatic rate of cooling--3.2 F temp. decrease per 1,000' increase in elevation.
4,500'
Between 4,500' and 7,000' the dew point has been reached and clouds develop
dry adaiabatic rate of cooling--5.5 F temp. decrease per 1,000' increase in elevation
moist air being forced to rise
0'

'Air Masses'

Large masses of air, which, due to the stable conditions of the land or water over which they develop, have a tendency to exhibit certain homogeneous characteristics in relation to temperature and humidity when a horizontal cross section is examined. Known as source regions, these persistant climatic factors which evolve here not only dominate the weather patterns of that particular region, but are also responsible for influencing those lands adjacent to them. So, lands which are consistantly warm and dry will most likely develop air masses which are warm and dry.

Having been given the task of specifically catagorizing air masses around the world, climatologists have developed a system of code letters used in identifying the traits of temperature and humidity. In turn, these characteristics can be used in determining how they relate to the climatic development of an area. The following is a list of the code letters and their meanings:

Humidity: (lower case letters)

c- continental (dry)
m- maritime (moist)

Temperature: (upper case letters)

E- Equatorial (hot)
T- Tropical (warm)
P- Polar (cold)
A- Arctic (very cold)- Northern Hemisphere
AA- Antarctic (very cold)- Southern Hemisphere

Putting all of this into practical use, the following chart, in conjunction with a map of North America will depict the specific source regions of the continent along with the air masses which evolve there.

Air Mass	Characteristics	Location
mP- maritime Polar	moist and cold	Gulf of Alaska
cP- continental Polar	dry and cold	MacKenzie River Valley
cA- continental Arctic	dry and very cold	Northern islands of Canada
mP- maritime Polar	moist and cold	South of Greenland-Atlantic
mT- maritime Tropical	moist and warm	West of the Baja Pen.-Pacific
cT- continental Tropical	dry and warm	Northern Mexico
mT- maritime Tropical	moist and warm	Gulf of Mexico
mT- maritime Tropical	moist and warm	East of Florida- Atlantic

66½
70
80
33
60
50
40
30
23½
20
10
0
130
120
110
100
40
90
80
70
mP
P
mP
mT
T
mT
mT

As geographers often do, the next logical step would be to compare this map of the air masses influencing the continent of North America with a map showing the specific climates located in those areas. What you will find is the by associating specific climates with specific air masses, circumstances don't always seem to work out. As you are probably aware, too many other factors play a part in the shaping of the overall atmospheric conditions displayed in certain regions.

'Storms'

The final phase of climatic influences deals with a specific type of atmospheric disturbance known as a Tropical Cyclone or Hurricane. While this awesome power of nature develops only over those areas of the Earth influenced by the warm tropical waters and air masses originating there, the entire realm, or area into which it spreads makes it a definite force which must be faced by all life forms. Thus far, we have made reference to such thunderstorms produced by the forces of orographic uplift and monsoons. Granted, these storms bring with them tremendous quantities of precipitation as they move inland, but relatively speaking, their effect is somewhat minute in comparison. The key ingredient missing is the forcefulness of the wind.

Tropical Cyclones, extremely intense areas of low pressure, develop over the tropical oceans where the topography is flat and there is an abundance of heat and humidity. While meteorologists cannot actually predict the occurrence of these storms with impunity, they can tell us when atmospheric conditions are such that there is a good possibility of one developing. They do this by tracking the stages leading up to their full development. The following is a list of these phases and a description of each:

Tropical Disturbance

As a weak interruption in the overall pattern of wind and air pressure evolves, a moving area of thunderstorms which maintains it's identity for a period of 24 hours or more begins to show up as weather satillites from space and weather radar track it.

Tropical Depression

As the storm entere this phase of it's development, it's true identity begins to take shape. For the first time, a rotary circulation of air at the surface with a steady and consistant wind speed of 38 mph develops.

Tropical Storm

Drawing it's strength from the warmth and humidity of the tropical oceans, the next phase is noted by an increase in the velocity of the wind. Here, distinctive rotary circulation at the surface with the highest wind speeds ranging from 39-73 mph exist.

Hurricane

With the atmospheric forces of nature at full swing, this final phase produces a pronounced rotary circulation of air with wind speeds in excess of 74 mph.

Needless to say, the ramifications of this storm can be devistating. To bring this point closer to home, let's examine an area which is located east of the sub-continent of India known as the Bay of Bengal. Being that a majority of the Earth's tropical cyclones develop here, this region is commonly refered to as "Hurricane Alley". It was here, in November of 1970, that the worst natural distaster of the 20th century occurred. With wind speeds in excess of 200 mph, a hurricane swept up the Ganges River Delta into the area of Dacca, Bangladesh. It wasn't until the flood waters had receeded and a survey of the region could be accessed that those who were there and witnessed the aftermath began to realize how staggering the casualties were. According to the "Readers Digest Almanac and Yearbook", 500,000 people had lost their lives as a direct result of the storm. To add insult onto injury, however, the available supply of freshwater, so vital to any civilization, had become contaminated leading to much sickness and many other deaths. With the help of many nations from around the world responding immediately with medical and finacial aid, this region eventually nursed itself back to approximately the same status it held before the storm. The only problem is, hurricanes still come on a yearly basis reminding those who choose to remain here just how much climate influences their daily existance.

**Note

A hurricane also is called or refered to by other names:
Typhoon- Pacific Ocean region.
Cyclone- Indian Ocean region- actually what the November, 1970 storm was called.
Wooly-Wooly- Australian region

The Koppen Climatic Classification System

In an analysis of standard means by which climates of the world are classified, one method stands out as being the basis from which all others received their beginnings and are thus compared. Known as the Koppen Climatic Classification, this method has been generally accepted and used by more climatologists than any other since it's conception in the year 1900 by the German climatologist and meteorologist Dr. Waldimir Koppen (1846-1940). As we begin to discuss this means of both organizing and distinguishing the many climates of the Earth, it will once again become very obvious that the two climatic traits of temperature and precipitation are still the most important factors one has to deal with.

As Koppen began this most arduous task, he came to the conclusion that perhaps the best method by which these statistics could be expressed was through the use of a code. Consequently, the most logical symbols he could think of were the upper and lower case letters of the alphabet. As you begin to read through the following detailed description of this noted method, note the relationship each symbol has with specific temperatures and amounts pf precipitation. Also keep in mind that the practicle application Koppen set down in his works is based upon those climatic influences discussed earlier in this unit.

Koppen's Climatic Classifications[3]

I. "A" Tropical Rainy Climates

1. The average temperature of every month is above 64.4° F (18° C).
2. These climates have no actual winter season (calendar only).
3. The annual rainfall is large and exceeds the annual evaporation.
4. Small letter classifications

"f" Tropical Rainforest (Af)
Rainfall of the driest month is 2.4" (6cm) or more.
Supports tropical and equatorial rainforest vegetation.

"m" Tropical Monsoon (Am)
Rainfall of the driest month is less than 2.4" (6cm).
Dry period of short duration.
Ground remains saturated enough to support tropical and equatorial rainforest vegetation.
The canopy of the monsoon forest is open due to the dry period.
Trees here are of the deciduous variety.
Dry season is during the low sun period and cooler temperatures.

"w" Tropical Savanna- wet and dry (Aw)
At least one month has rainfall which is less than 2.4" (6cm).
Dry season is strongly developed during the winter.
A transition zone between the forests and grasslands.
Widely scattered trees rising from broad expanses of grass.
Tropical Savanna includes woodland, thornbush, scrub, and grassland.
Determine the Am and Aw boundary by using the following formula:

$$r = \frac{98.4 - (\text{Annual Precipitation})}{25}$$

r = rainfall of the driest month
Am has more and Aw has less than the boundary formula

"w'" Rainfall maximum in Autumn.
"w''" Two distinct rainy and dry seasons.
"s" Dry season during the summer (rare).
"i" Range in temperature between the warmest and coldest month is less than 9° F.
"g" Ganges area-hottest month comes before the solstice and the summer rainy season.

II. "B" Dry Climates

1. Evaporation exceeds precipitation on the average throughout the year.
2. Since there is no water surplus, there are no permanent streams originating in the "B" climate zones.
3. "BW" Arid Desert
   As a general rule of thumb, any area which receives less than 10" of rainfall during the course of a given year exhibits qualities of being a desert.
   Xerophytic vegetation is widely dispersed and provides negligible ground cover.
4. "BS" Semi Arid Steppe
   As a general rule of thumb here, rainfall is in the range of 10-20" per year.
   Xerophytic shrub vegetation with a very sparse lower shrub layer.
5. Boundary Formula BS-BW

   even precipitation $r = \frac{0.44t - 8.5}{2}$

   winter drought "w" (see explanation) $r = \frac{0.44t - 3}{2}$

   summer drought "s" (see explanation) $r = \frac{0.44t - 14}{2}$

6. Small letter classifications

   "h" (heiss) hot and dry.
   Mean annual temperature is over 64.4° F (18° C) "B" climates only.
   BWh- Tropical Desert
   BSh- Tropical Steppe

   "k" (kalt) cold and dry
   Mean annual temperature is under 64.4° F (18° C) "B" climates only.
   BWk- Middle Latitude Desert
   BSk- Middle Latitude Steppe

   "k'" Temperature of the warmest month is under 64.4° F (18° C)

   *"s" Summer drought
   At least 3 times the precipitation in the wettest winter month as in the driest summer month.

   *"w" Winter drought
   At least 10 times as much precipitation in the wettest summer month as in the driest winter month.

   "n" Nebel- frequent fog

III. "C" Humid Mesothermal or Mild Temperate Rainy Climates

1. The average temperature of the coldest month is below 64.4° F (18° C) but above 26.6° F (-3° C).
2. The average temperature of the warmest month is above 50° F (10° C).
3. These climates actually go through 4 noticeable changes in the seasons.
4. Small letter classifications

"f" No distinct dry season.
The rainfall of the driest summer month is at least 1.2 inches.

"w" Winter drought- at least 10 times as much precipitation in the wettest summer month as in the driest winter month.
Defined the same as the "B" climate.
Also located in the elevated sites of the low latitudes where altitude reduces the temperature of the Aw climates which prevail in the adjacent lowlands.
Mild middle latitude monsoon lands of southern Asia, northern India and southern China.

"s" Summer drought- at least 3 times as much precipitation in the wettest winter month as in the driest summer month.
Defined the same as the "B" climate.
Sclerophyll forest vegetation.

"a" With a hot summer (Humid Sub-tropical)
The average temperature of the warmest month will be over 71.6° F (22° C).
Vegetative types:
Temperate rainforests
Middle latitude deciduous forest
Prairie- tall grass

"b" With a warm summer (Marine West Coast)
The average temperature of the warmest month will be below 71.6° F (22° C).
Temperate rainforest vegetation.

"c" With a cool summer (Marine West Coast)
Less than 4 months (3) have an average temperature exceeding 50° F (10° C)
Temperate rainforest vegetation.

"x" Rainfall maximun in the late spring or early summer- drier in the late summer.

"i" Range of temperature between the warmest and coldest months is less than 9° F.
Defined the same as in the "A" climate

"g" Ganges area- hottest month comes before the solstice and the summer rainy season.
Defined the same as in the "A" climate.

"n" Nebel- frequent fog
Defined the same as in the "B" climate.

5. Boundary formula between C-D climates

even precipitation	$r = 0.44t - 8.5$
"w" winter drought (see explanation)	$r = 0.44t - 3$
"s" summer drought (see explanation)	$r = 0.44t - 14$

r = annual precipitation
t = annual temperature

IV. "D" Humid Microthermal or Cold Snow Forest Climates

1. The average temperature of the coldest month is below 26.6° F (-3° C).
2. The average temperature of the warmest month is above 50° F (10° C).
3. Isotherms coincide approximately with the poleward limit of tree growth.
4. Small letter classifications
   - "f" Cold climate with humid winters.
     No distinct dry season.
     The rainfall of the driest summer month is at least 1.2".
     Defined the same as in the "C" climate.
   - "w" Cold climate with a dry winter (winter drought).
     At least 10 times as much precipitation in the wettest summer month as in the driest winter month.
     Defined the same as in the "B" climates.
   - "s" Summer drought
     At least 3 times the precipitation in the wettest winter month as in the driest summer month.
     Defined the same as in the "B" climate.
   - "a" Humid Continental- long summer
     The average temperature of the warmest month will be over 71.6° F (22° C).
     Defined the same as in the "C" climate.
     Middle latitude deciduous forests
   - "b" Humid Continental- short summer
     The average temperature of the warmest month will be below 71.6° F (22° C).
     Defined the same as in the "C" climate.
     Needleleaf forests.
   - "c" Sub Arctic or Taiga
     Less than 4 months (3) have an average temperature exceeding 50° F (10° C).
     Defined the same as in the "C" climates.
     Needleleaf forests.
   - "d" Sub Arctic or Taiga
     The average temperature of the coldest month is below -36.4° F (-38° C)
     "D" climates only- very cold winters
     Needleleaf forests
5. Boundary formula between C-D climates

even precipitation	$r = 0.44t - 8.5$
"w" winter drought (see explanation)	$r = 0.44t - 3$
"s" summer drought (see explanation)	$r = 0.44t - 14$

r = annual precipitation
t = annual temperature

V. "E" Polar Climates (Boreal)

1. The average temperature of the coldest month is below 50° F (10° C)
2. These climates have no true summer
3. Classifications
   "ET" Tundra Climate
   The mean temperature of the warmest month is above 32° F (0° C) but below 50° F (10° C).
   Vegetation consists of Arctic grassy tundra and Alpine tundra.
   "EF" Perpetual Frost Climate
   Ice Sheet Climate
   The mean monthly temperatures of all months are below 32° F (0° C).

Koppen Classification	Conventional Names
Af	Tropical Rainforest
Am	Tropical Monsoon
Aw	Tropical Savanna
BSh and BSk	Steppe
BWh and BSh	Desert
Cfa	Humid Subtropical
Cfb and Cfc	Marine West Coast- Mid-Latitude
Cwa	Suntropical Monsoon
Cwb	Tropical Upland
Csa and Csb	Mediterranean
Dfa and Dwa	Humid Continental- Hot Summer
Dfb and Dwb	Humid Continental- Warm Summer
Dfc and Dwc	Subarctic
ET	Tundra
EF	Icecap

'The Practicle Application of Koppen's System'

Now that we have a basis from which to work, perhaps the most practicle approach is to observe how the use of statistical data pertaining to temperature and precipitation can be used in identifying specific climates from around the world. The following climatic data, along with the outline of Koppen's Climatic Classification, will serve as our working example:

Climatic data for Boston, Massachusetts	Month	Temperature (° F)	Precipitation
	January	28	3.6
	February	29	3.3
	March	36	3.8
	April	46	3.5
	May	57	3.1
	June	67	3.2
	July	71	3.3
	August	70	3.6
	September	63	3.2
	October	54	3.3
	November	42	3.6
	December	33	3.4
	Year	50	40.9

Upon your initial inspection of Koppen's system, you probably took notice of his use of temperature data as the distinguishing factor differentiating climates. The one exception revolves around those areas classified as the Dry Climates ("B) where precipitation is the major factor.

Keeping these two points in mind, let's turn our total attention now to the climatic classification of Boston through the use of the given climatic data. In order to accomplish this, the following steps should be used to insure the proper results:

1. Check the yearly total of precipitation to see if it should be placed in the "B" catagory of Dry Climates as the criteria states.
2. If the above proves to be correct, use the small letter classification of "h" or "k" as described under the "B" catagory, whichever applies.

3. If the response to #1 is incorrect, take note of the highest and lowest monthly temperature averages for the climatic station in question.

4. Compare these averages to the criteria designated within each major climatic catagory and choose the correct one, under which the given station belongs.

5. Once a major climatic catagory has been determined, re-examine the precipitation and temperature data, if neccessary, and choose either an "f", "s", or "w" for precipitation and an "a", "b", "c", or "d" for temperature and add those to the major classification catagory.

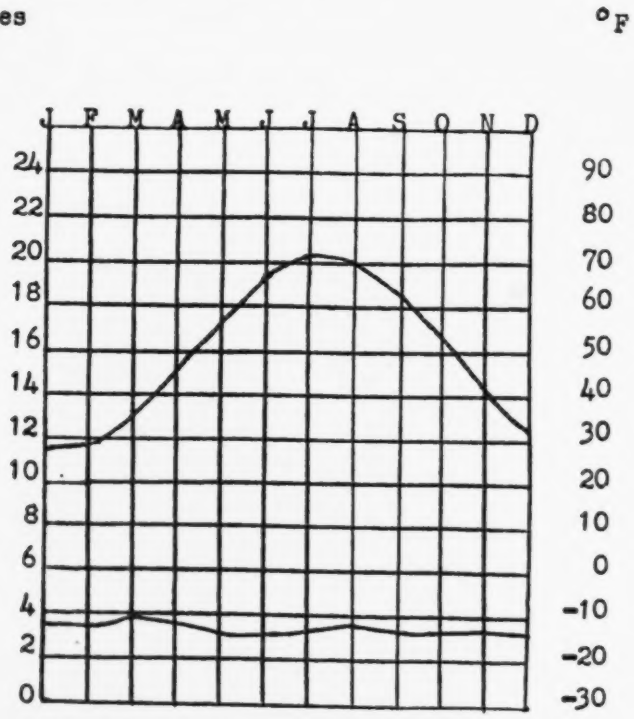
If the preceeding steps are followed, you should arrive at the conclusion that Boston has a Cfb (Mid-Latitude Marine) climate. Here is why.

"C" Boston's lowest temperature (28° F) and highest (71° F) falls within the "C" catagory because the average temperature of the coldest month is above 26.6° F but below 64.4° F while the average temperature of the warmest month is above 50° F.

"f" Boston has no distinct dry season because the rainfall of the driest summer month (August at 3.6") is above 1.2".

"b" Boston has a warm summer because the average temperature of the warmest month (July at 71° F) is below 71.6° F.

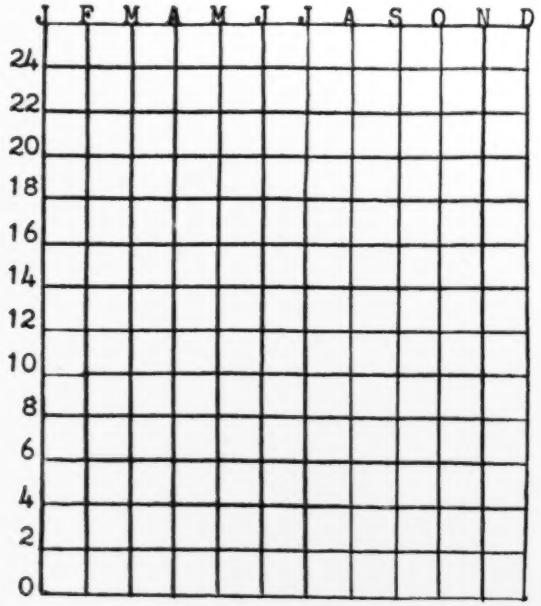
The accompanying climagraph depicts what a pictorial representation of Boston's temperature and precipitation data would look like.



Climatic station Boston, Mass.

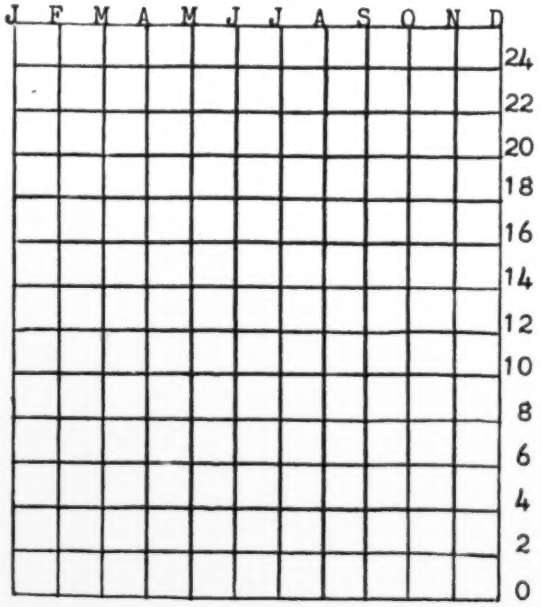
Climatic type Cfb

inches °F inches



Climatic station _____

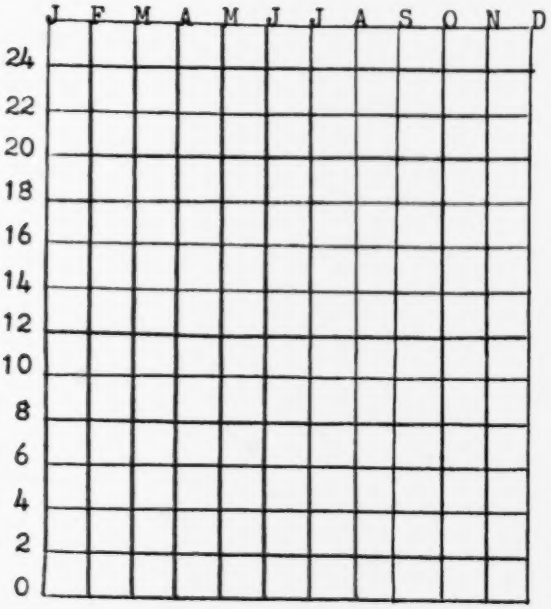
Climatic type _____



Climatic station _____

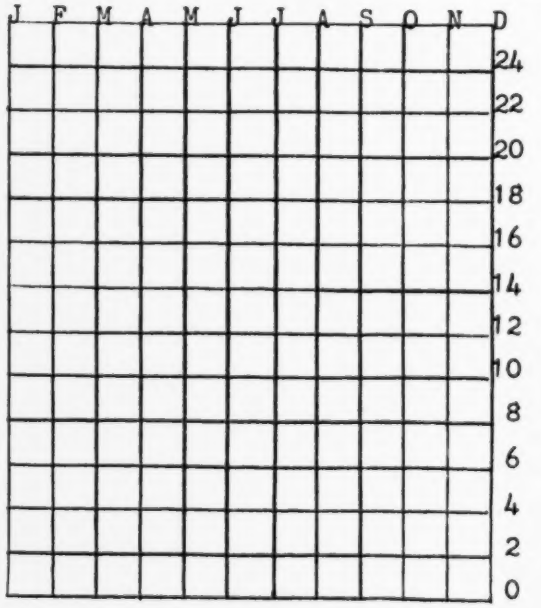
Climatic type _____

inches °F inches



Climatic station _____

Climatic type _____



Climatic station _____

Climatic type _____

SINGAPORE, MALAY PENINSULA

														TYPE
RAIN	9.9	6.8	7.6	7.4	6.8	6.8	6.7	7.7	7.0	8.2	10.0	10.1	95.0	
TEMP	79	80	81	81	82	82	81	81	81	80	80	80	81	———

ODESSA, UKRAINE-USSR

RAIN	0.9	0.7	1.1	1.1	1.3	2.3	2.1	1.2	1.4	1.1	1.6	1.3	16.1	
TEMP	25	28	35	48	59	68	73	71	62	52	41	31	49	———

BARCELONA, SPAIN

RAIN	1.2	2.1	1.9	1.8	1.8	1.3	1.2	1.7	2.6	3.4	2.7	1.8	23.5	
TEMP	49	51	54	57	64	70	75	76	71	65	56	50	62	———

COLON, PANAMA

RAIN	3.9	1.7	1.7	4.2	12.6	13.5	17.2	14.9	12.5	14.8	21.5	11.9	130.4	
TEMP	80	79	80	80	80	80	80	79	80	79	79	80	80	———

NARVIK, NORWAY

RAIN	1.9	1.7	2.4	1.8	1.6	2.7	2.3	3.3	3.8	3.3	2.2	2.4	29.4	
TEMP	23	23	25	33	40	50	56	53	47	38	30	27	37	———

KUCHA, CHINA

RAIN	0.1	0.1	0.2	0.1	0.1	1.3	0.7	0.3	0.2	0.0	0.0	0.3	3.4	
TEMP	9	25	45	55	64	71	76	72	64	54	35	19	49	———

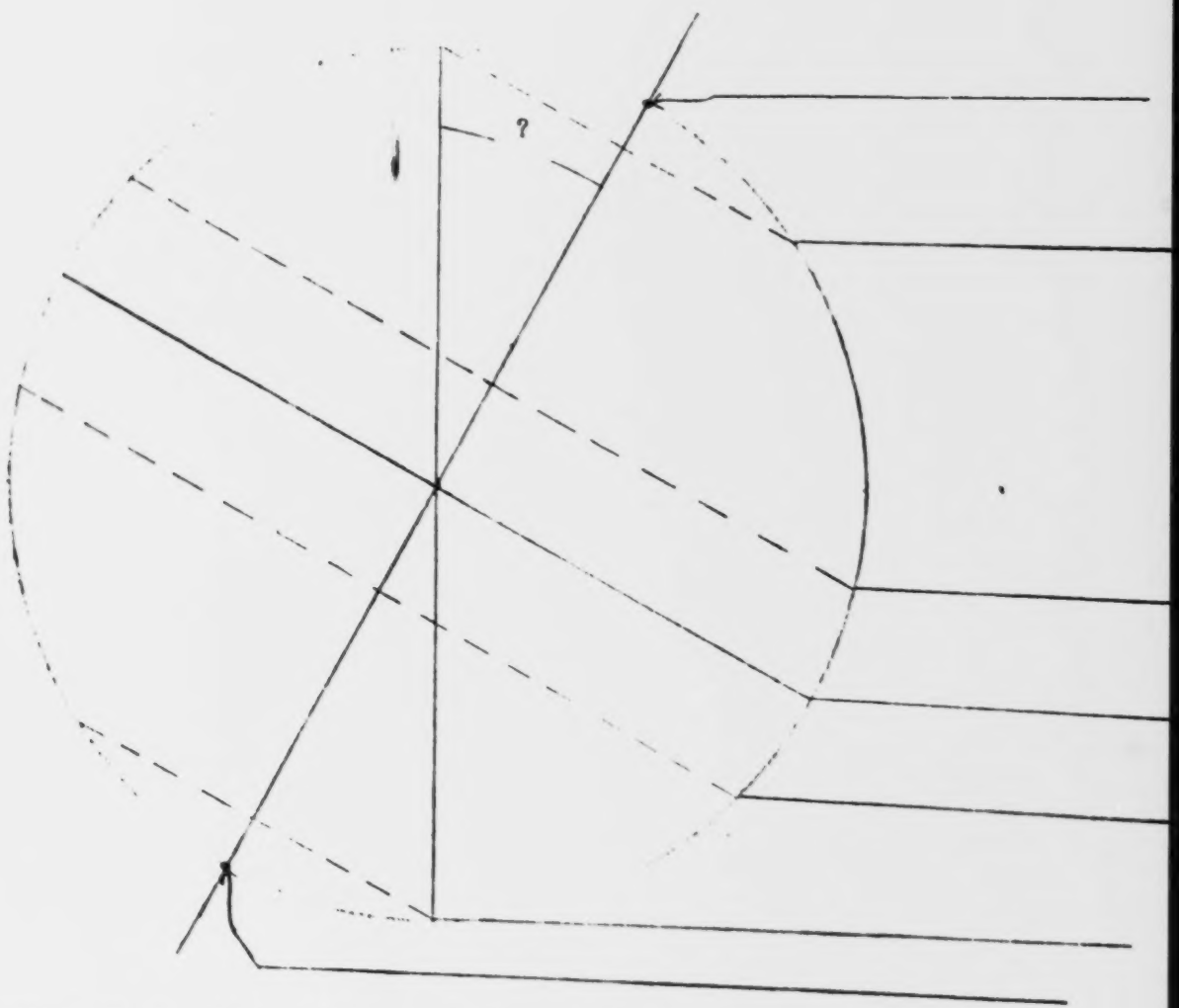
VOSTOV, ANTARCTICA

RAIN	NO		DATA			AVAILABLE								
TEMP	-25	-41	-71	-85	-86	-88	-86	-94	-87	-70	-47	-27	-67	———

	SINGAPORE, MALAY PENINSULA													TYPE
RAIN	9.9	6.8	7.6	7.4	6.8	6.8	6.7	7.7	7.0	8.2	10.0	10.1	95.0	
TEMP	79	80	81	81	82	82	81	81	81	80	80	80	81	———
	ODESSA, UKRAINE-USSR													
RAIN	0.9	0.7	1.1	1.1	1.3	2.3	2.1	1.2	1.4	1.1	1.6	1.3	16.1	
TEMP	25	28	35	48	59	68	73	71	62	52	41	31	49	———
	BARCELONA, SPAIN													
RAIN	1.2	2.1	1.9	1.8	1.8	1.3	1.2	1.7	2.6	3.4	2.7	1.8	23.5	
TEMP	49	51	54	57	64	70	75	76	71	65	56	50	62	———
	COLON, PANAMA													
RAIN	3.9	1.7	1.7	4.2	12.6	13.5	17.2	14.9	12.5	14.8	21.5	11.9	130.4	
TEMP	80	79	80	80	80	80	80	79	80	79	79	80	80	———
	NARVIK, NORWAY													
RAIN	1.9	1.7	2.4	1.8	1.6	2.7	2.3	3.3	3.8	3.3	2.2	2.4	29.4	
TEMP	23	23	25	33	40	50	56	53	47	38	30	27	37	———
	KUCHA, CHINA													
RAIN	0.1	0.1	0.2	0.1	0.1	1.3	0.7	0.3	0.2	0.0	0.0	0.3	3.4	
TEMP	9	25	45	55	64	71	76	72	64	54	35	19	49	———
	VOSTOV, ANTARCTICA													
RAIN	NO		DATA		AVAILABLE									
TEMP	-25	-41	-71	-85	-86	-88	-86	-94	-87	-70	-47	-27	-67	———

Questions for Assistance

1. List 5 proofs of the Earth's sphericity.
2. Describe the actual shape of the Earth. How do the polar and equatorial diameters confirm this?
3. What is the zenith position of the sun?
4. Who first calculated the circumference of the Earth?
5. Complete the following diagram:



6. What determines the location of the "tropics" and "circles"?

Questions for Assistance

1. Who proposed the following theories and how were they different?
   a. geocentric theory
   b. heliocentric theory

2. List the two major movements of the Earth and what is primarily responsible for both.

3. _____ is the spinning of the Earth around it's axis.

4. List 4 proofs of the Earth's rotation.

5. List and describe the 2 effects rotation has upon the Earth.

6. Describe differential rotation as it applies to the Earth.

7. What is the velocity of the Earth's rotation at the poles and why?

8. _____ is the movement of the Earth around the sun.

9. Describe the terms "aphelion" and "perihelion".

10. What determines the seasons of the Earth

11. List 2 proofs of the Earth's revolution.

12. Define the terms "equinox" and "solstice".

13. Where is the zenith position of the sun in relation to the Earth in the Northern Hemisphere at the beginning of the following seasons:
   a. Autumnal Equinox?
   b. Winter Solstice?
   c. Vernal Equinox?
   d. Summer Solstice?

14. On the average, how fast does the Earth travel through space in it's orbit around the sun?

Questions for Assistance
Latitude-Land and Water

1. How does weather differ from climate?

2. List the 7 elements which constitute the make up of climate.

3. In general, how does latitude influence temperature?

4. Define insolation.

5. Using analemma, determine the noon sun angle over the following locations:
   a. 77 South on December 21.
   b. 48 North on September 28.

6. What happens to air which is warmed? which is cooled?

7. Why does land heat up and cool off much faster than water?

8. Describe the air flow exhibited by pressure cells and the cause of this movement.

9. Describe areas of divergence and convergence.

10. In reference to the general circulation of the atmosphere, list the 4 major pressure cells of the Earth beginning with the equatorial region and progressing toward the poles along with their latitudinal locations.

    Along the same line of reference, list the 3 major wind systems created by these pressure belts along with their latitudinal locations.

11. _____ refers to a seasonal wind created by the seasonal reversal of pressure cells over a given area.

12. Describe the differences between summer and winter monsoons.

13. How do land and sea breezes differ?

14. Write a brief description of the following:
    a. Mountain and Valley Breeze.
    b. Chinook or Foehn winds.
    c. Katabatic winds.
    d. Santa Ana or Sirocco winds.

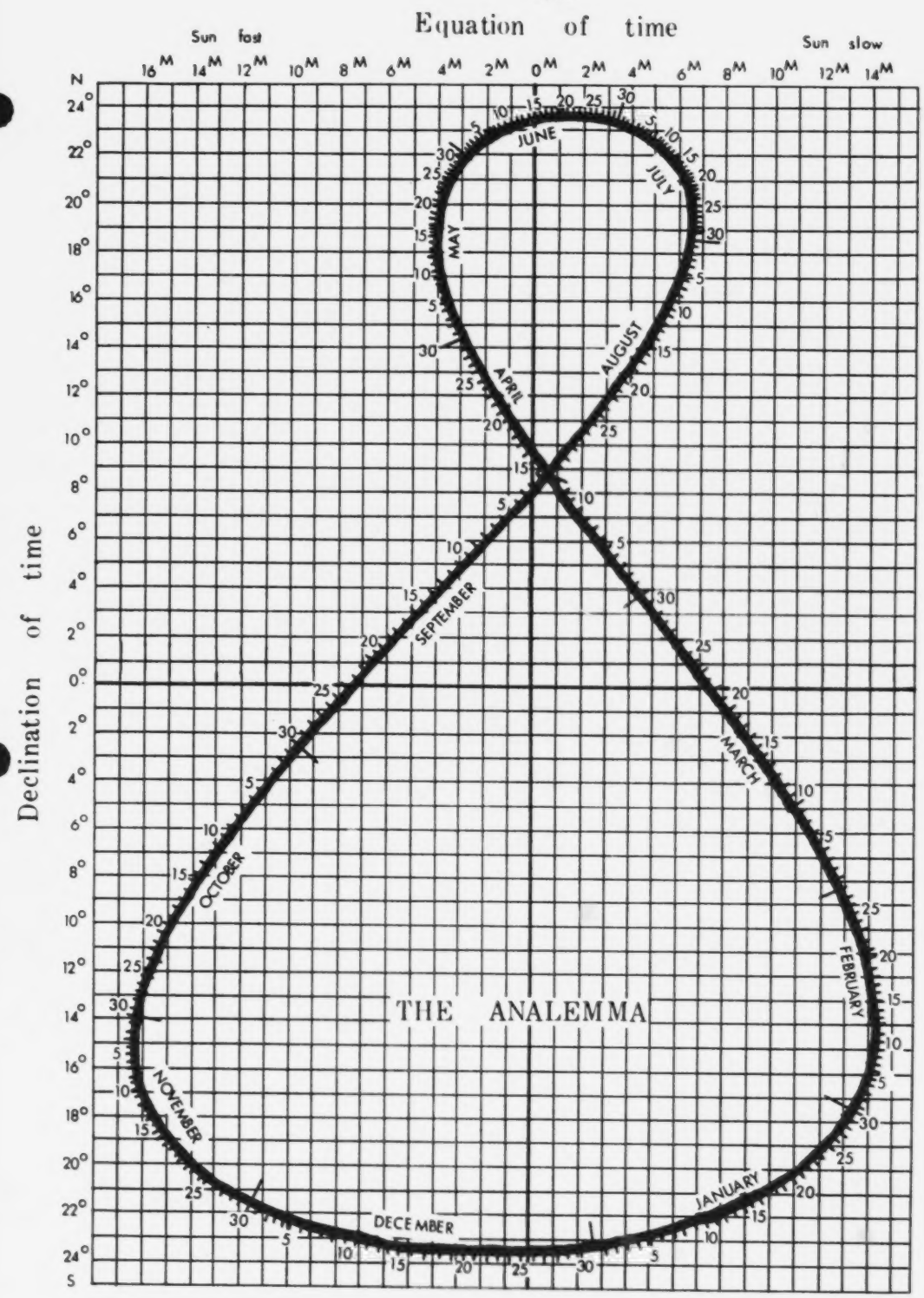
Ocean Currents-Topography

1. Describe what affect ocean currents have upon climate.

2. _____ is height above a given surface.

3. How does altitude affect temperature?

4. What atmospheric criteria must be present before the Normal Lapse Rate can be used in figuring air temperature?


Equation of time
Sun fast
Sun slow
16M 14M 12M 10M 8M 6M 4M 2M 0M 2M 4M 6M 8M 10M 12M 14M
Declination of time
N
24° 22° 20° 18° 16° 14° 12° 10° 8° 6° 4° 2° 0° 2° 4° 6° 8° 10° 12° 14° 16° 18° 20° 22° 24°
S
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
THE ANALEMMA

5. Given a surface temperature of 76 F., use the Normal Lapse Rate in calculating the air temperature at an altitude of 12,500'.

6. Distinguish between altitude and elevation.

7. Define the Wet and Dry Adiabatic Rates of cooling and when each should be used in the calculation of air temperature.

8. Using the same mountain diagram depicted on page of the text along with the Wet and Dry Adiabatic Rates of cooling, calculate the air temperatures at 4,500', 7,000', 12,750', and at the base of the leeward side of the mountain when the temperature at the base of the windward side of the mountain is 84 F.

   Why is the temperature warmer at the leeward base than the windward base?

Air Masses-Storms

1. What are air masses?

2. Describe the term "source region" and tell what these areas have to do with the development of air masses.

3. List the 2 characteristics of air masses.

4. Describe the following air mass codes:
   c-
   m-
   E-
   T-
   P-
   A-
   AA-

5. Describe the 4 stages leading up to the development of Hurricanes.

Questions for Assistance

1. Using Koppens Climatic Classification process, identify each climatic station displayed on pages of the text.

AN INTRODUCTION TO LANDFORMS

How each of us perceives the topographical features of the earth, needless to say, varies from person to person. Throughout history, we have read accounts pertaining to descriptions of our natural wonders, but reading cannot come close to describing the feeling we get when we first set our eyes on such features as the Grand Canyon, as carved out by the Colorado River, or the Serengeti Plains of east Africa with Mt. Kilimanjaro as a backdrop. These majestic formations are the result of both internal and external forces which shape the earth and give it the uniqueness it so richly deserves. While examining these landscapes, we will focus our attention on:

- The Characteristics of Landforms
- The Internal Structure of the Earth
- Plate Tectonics
- Relief Features of the Earth
- Volcanoes
- Earthquakes
- Glaciers

THE CHARACTERISTICS OF LANDFORMS

Landforms can be defined as any of the physical or inorganic features of the earth which have relief and are formed naturally. While this definition is not complicated, the overall study of landforms (Geomorphology) must be approached from a scientific viewpoint due to the number of internal, as well as eternal, forces which affect them. Geomorphologists, scientists who study both the formation and destruction of landforms, must have a working knowledge of such diverse sciences as geology, geography, chemistry, volcanology, seismology, glaciology, meteorology as well as many others which have a direct and indirect affect upon topographical features.

Initially, what we know, is that regardless of shape or size, all landforms have 3 common traits or characteristics they share. The most obvious is elevation. Being the height above or below the datum plane of sea level, elevation offers us a vertical perspective of the earth's features in relation to what we perceive as a horizontal plane. As you already know, the level of the sea changes daily due to the tides. For this reason, that point directly in between high and low tide (known as the datum plane) has been chosen as 0 feet elevation, or sea level. From this point, our landformations are measured, but let's not forget that elevation also extends below that of sea level. An excellent case in point would be a comparison of Mt. Everest with the volcanic peak of Mauna Kea.

Located within the country of Nepal in the Himalaya Mountains, Mt. Everest is said to be the tallest mountain in the world. At the present, it has an elevation of 29,108 feet and is still growing. While it is true you cannot stand anywhere else on the face of the earth and be at a higher elevation, Everest is not the tallest mountain. Rising out of the depths of the Pacific Ocean on the big island of Hawaii, Mauna Kea soars to a height of 13,796 feet above sea level with a total elevation of 33, 476 feet. By the use of simple subtraction, you can see that

19,680 feet is situated below the surface of the Pacific. The difference is in how we judge the height.

The second characteristic has to do with relief. Defined as the difference in distance between the highest and lowest points in elevation of a given area, relief is the criteria geomorphologists use in the classification of landforms. If we have the summit of a mountain reaching an elevation of 10,000 feet with an adjacent valley being that of 5,000 feet, the relief of the area would be 5,000 feet. Keeping this procedure in mind, certain terms associated strictly with landforms are derived from this method. The following chart will clarify this:

Relief	Associated Landform
0-300 feet	Plains
300-1000 feet	Hills
1000-2000 feet	High Hills or Low Mountains (sometimes refered to as foothills)
over 2000 feet	Mountains

The descriptive definitions dictionaries and certain texts give, which do not refer to relief, are written so people can make mental images of these landforms. Unless you have aquired a basic understanding of the concept of relief, the scientific definition would have very little, if any, meaning.

The final trait landforms exhibit is slope. Several descriptive adjectives such as slant or steepness can be used to identify this characteristic, however, the term configuration seems to put everything into proper perspective here. To anyone who has done any traveling at all, the most noticeable slopes are those which are very steep. While driving into or out of a mountainous region, slope is very apparent. The difference comes with the subtle increase in elevation as you travel across a broad stretching plain into a mountainous region. Here the increase in the slope in not very apparent at all. By analyzing a topographical relief map of the United States, this gradual increase is shown as the Great Plains approach the Rocky Mountains.

THE INTERIOR STRUCTURE OF THE EARTH

Since the turn of the 20th century, our accumulation of knowledge has been rather phenomenal, to say the least. Concepts and questions which seemed unattainable are now considered common understandings. One such field has to do with the earth's interior. Prior to the development of the seismograph and our in depth study of earthquakes, geologists had to rely on whatever pieces of evidence the earth chose to leave us. Through the process of uplifting, the examination of those rocks which had been buried deep beneath the earth's surface are now available for our study. The close inspection of the mineral varieties and structure in what was once sedimentary rock has also given us valued insight. The transformation of the sedimentary rock into metamorphic occurs under extreme exposure to heat and pressure.

By piecing these clues together, geomorphologists have been able to develop quite a picture of the forces at work inside the earth. All matter tends to be held together by gravitational attraction with the strongest attraction being directed towards the center of the earth. Weight is thus a product of twothings, mass (the quantity of matter) and the strength of the gravitational attraction. Because of the surrounding rock, pressure on a small particle of rock is not only downward, but also inward from the sides and upward from the bottom. A useful unit used to measure this pressure inside the earth is the atmosphere. One atmosphere of pressure is equivelant to 14.7 pounds per square inch. Obviously, the closer you get to the center of the earth, the greater is the pressure. About 1/3 of the distance down to the earth's center approximately 1,000,000 atmospheres exists. Let's go one step further. Imagine, if you will, that point which is at the very center of the earth. Any direction from that point would be up towards the surface. This means that the entire weight of the earth is focused on that one point. Refered

to as the center of gravity, the pressure here is equal to $3\frac{1}{2}$ million atmospheres, or 51,450,000 pounds per square inch. Almost incomprehendible isn't it?

Temperatures increase also as you get closer to the center of the earth. Much of this is brought on by the radioactive decay of certain minerals within rocks which lie relatively near the earth's surface. This increase in temperature in conjunction with the intense pressure inside the earth give rise to an entirely different environment. Due to this environment, the 2 concepts of liquid and solid, as applied to the earth's interior, are quite unusual. The term liquid refers to a molten rock material while a solid actually relates to 3 different consistencies. A solid can be either crystalline, elastic (able to be shaped without breaking) or brittle. Keeping this in mind, let's look now at how we know what the earth's interior consists of.

When the plates suddenly slip and an earthquake occurs, three different types of shockwaves are sent out from the focus. Classified as body waves, it is the Primary and Secondary waves which travel through the earth. Primary waves, also known as Compressional or P-waves, are push-pull waves which will travel through any medium (liquid or solid). Being the fastest of all shockwaves, they reach recording or seismographic stations first.

Secondary waves, also known as Transverse, Shake or S-waves, will travel only through a solid medium. Here in lies the key which unlocks the mystery of the interiors consistency. Seismographic stations located in certain areas of the earth may only receive Primary waves after an earthquake due to the Secondary waves "bouncing" off a liquid portion of the earth's interior. In those areas where Secondary waves are recorded, however, they arrive behind the Primary.

Surface waves, the slowest of the shockwaves, reach a recording station last. Instead of traveling through the earth, these travel around the outside in a circular motion away from a center in all directions. More about earthquakes and seismographs (the instrument which records these shockwaves) will be discussed later.

'Concentric Layers'

Let's put together now what we have learned. Theoretically, if we could slice the earth directly in half, you would notice it is divided into 4 concentric layers, each completely overlapping the one directly below it. Through the study of earthquake shockwaves, scientists have confirmed the existance of a spherical core at the earth's center. If the earth were solid, the Primary and Secondary waves would travel through the earth's center in all directions. The shock of any large earthquake could be recorded at any seismographic station directly opposite the quake. It was soon discovered that the Secondary waves were not being received at such locations. Being that Secondary waves will not pass through a liquid medium, it was concluded that there was a liquid outer core surrounding a solid inner core. The solid inner core consists of a crystalline form due to the intense heat and pressure. With the temperatures estimated to be between 4,000 and 5,000 degrees Fahrenheit, the inner core has a radius of approximately 780 miles putting it's circumference at 4,898.4 miles.

The outer core is composed of liquid iron of great density existing under enormous pressure and high temperatures. Having a radius of 2160 miles, the circumference of the outer core is about 13,564.8 miles making it a little more the $\frac{1}{2}$ of the earth's circumference.

That portion of the earth's interior located between the outer core and the crust is called the mantle. Earthquake waves travel through this area at such high speeds that only a very rigid or dense rock could exist. This confirms the fact that this area is a solid but not in the same sense as the inner core. With the heat being much less intense, the rock here has an elastic quality meaning that under high pressure or stress it can be shaped without breaking.

The mantle is approximately 1,800 miles thick. Adding that to the radius of the inner core, 99$\frac{1}{2}$% of the total radius of the earth is located within these three inner layers. This leaves a rather thin outer shell roughly 20 miles thick on the average.

The crust is the outermost layer of the earth varying in thickness from 5-25 miles. Consisting of 2 layers, the area closest to the mantle is a continuous layer of basaltic rock while the uppermost layer is composed mainly of granite. The granite layer constitutes the bulk of the continents.

Through the work of the Yugoslavian seismologist Andrija Mohorovicic, it was discovered that a zone of separation between the mantle and the crust existed. Eventually named in his memory, the Moho Discontinuity has become an important discovery in our understanding of the earth's interior.

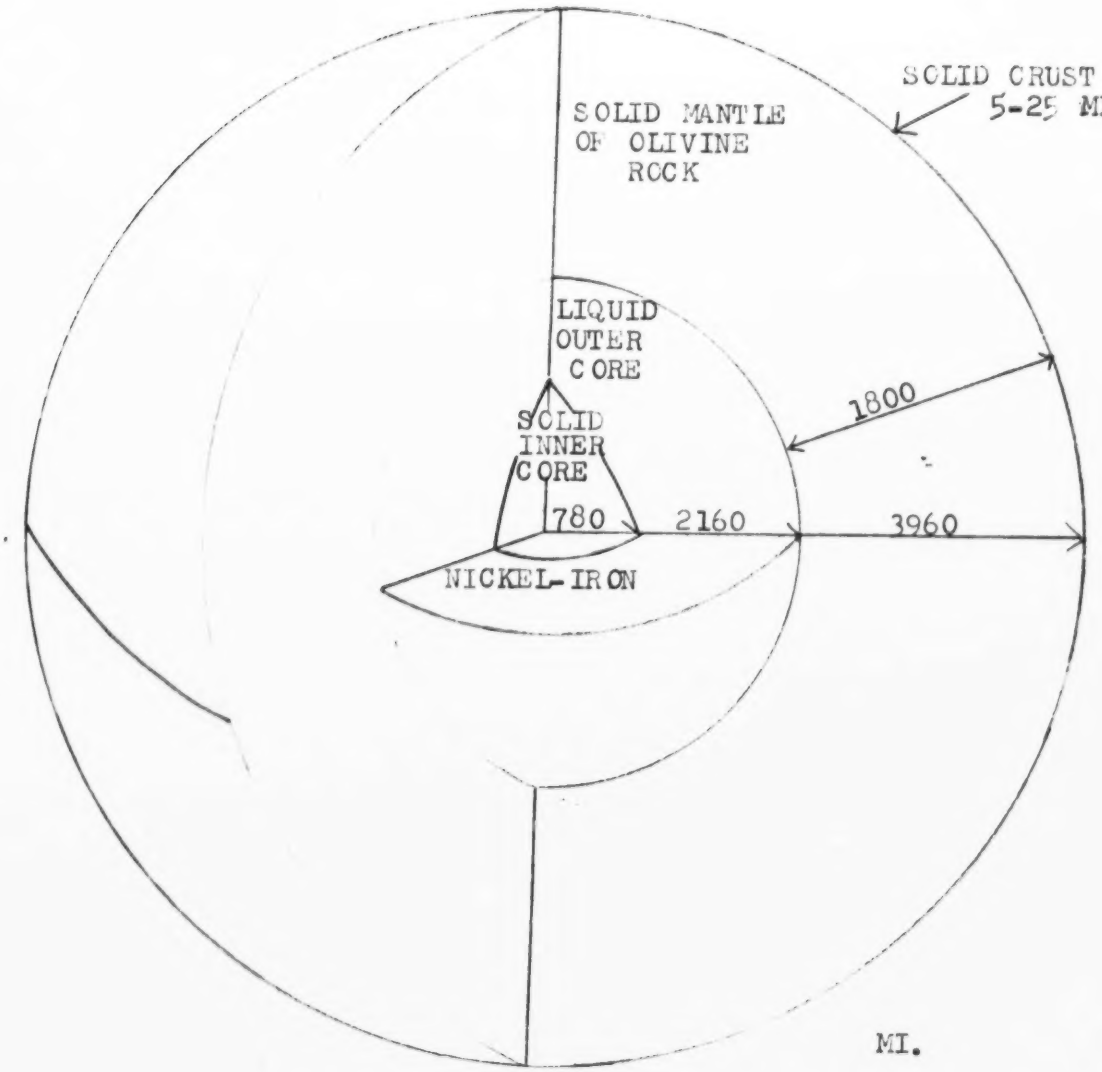


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PLATE TECTONICS

How many of you have ever looked at a world map and imagined the continents to be the pieces of an enormous jig-saw puzzle which could be fitted together. If you have, your not far off. During the 1920's, a German scientist named Alfred Wegener, pubilcally acknowledged such a possibility to several of his colleagues. Ironically, they were not quite ready to accept such a "proposterous" theory. Consequently, Wegener suffered the scorn and ridicule from a group of people who could not or would not recognize him for what he was, a man ahead of his times.

Coined the "Continental Drift", Wegener envisioned the continents, like huge rafts, drifting across the oceans. Technology, being what it was at that point in history, prevented him from seeing that more was involved than just the movement of the continents. Throughout our history of explorations, several discoveries had been made which didn't appear to have any logical explanation. Let's go over a few so you will understand what I am refering to.

The formation of coal can actually go through five phases before total completion. The first, known as the green plant stage, involves the growth of very lush green vegetation in and around tropical lake beds. The key word here is tropical. As these plants die, their remains are deposited on the lake floor where they begin to accumulate in consecutive layers year after year.

As the climate of this area begins to change and the lake dries up, the composition of these layers of sediment also changes and becomes what is known as peat. Peat can be dug and burned as a fuel, as it has been for centuries in Ireland.

If peat is allowed to remain in the ground for several million years, it eventually hardens into a type of coal known as lignite. Lignite has a low fuel value due to the fact it disintigrates rapidly upon burning.

After many millions of years, the composition of lignite too changes becoming

bituminous coal. Bituminous coal is used in the generation of electricity.

As with many rocks which are subjective to massive amounts of heat and pressure over extended periods of time, their whole atomic structure becomes re-arranged. These new metamorphic rocks are harder and more resistant to change. So it is with coal as well. This final phase of coal development is refered too as anthracite, the hardest and cleanest burning of all coal.

Now, getting back to our original premise, if coal first devlops in and around tropical lake beds abundant in vegetation, how can you explain the fact that coal has been found in Antarctica?

Continuing along the same line, think about the formation of oil. Again we are talking about the warm tropical waters of the earth, this time in the oceans. Within these waters lives an abundance of marine life. If this is the case, how do you explain the fact that large deposits of oil have been found off the north slope of the Brooks Range in Prudhoe Bay, Alaska? Prudhoe Bay is located in the Beaufort Sea which is neither tropical nor teeming with marine life.

How do you explain the fact that the Cabot fault of Newfoundland and the Great Glen fault of Scotland are separated by the Atlantic Ocean but are the same fault?

On the 29th of May, 1953, Sir Edmund Hillary and Tenzing Norkay became the first two men to actually scale and reach the summit of Mt. Everest. During subsequent expeditions, the fossilized remains of ancient sea creatures, having lived millions of years ago, were discovered strewn in the rocks at the base of the Himalaya Mts. This seemed very strange at the time.

Paleontologist have also added to the mysteries with some of their key findings. In their never ending search for ancient life, the fossilized remains of similar plants and animals were found on different continents separated by thousands of miles of oceans.

With the use of sophisticated measuring equipment, we now know that the Atlantic Ocean is getting wider each year. The Red Sea is really an ocean in the making. The Pacific Ocean is getting narrower each year. The island of Iceland is literally

coming apart at it's seems. Why?

The answer to these questions lies in what has perhaps been the most significant geological discovery made this century. Our concept of the "terra firma" earth was anything but true. The crust of the earth has actually been fractured into huge sections called plates. Known as Plate Tectonics, these plates move across the top of the mantle along the Moho Discontinuity at a rate of 1-3 cm. per year. As the plates move, they either collide with, pass beside or separate from other plates. Here is what geologists tell us has happened on the earth in the past.

Approximately 200 million years ago, the continents of the earth were all joined together into one giant supercontinent known as Pangaea, (meaning all lands). Pangaea was surrounded by one very large body of saltwater called Panthalassa, (meaning all seas). At this point in time, a giant east-west rift opend up dividing Pangaea into two very large continents separating it by a warm tropical sea. The continent to the north, Laurasia, consisted of the the present day landmasses of North America, Europe and Asia. To the south was Gondwana. Gondwana was made up of South America, Africa, Australia, Antarctica and India. Separating the two was a sea known as the Tethys Seaway. It was here, due to absolutely no influence of a cold water current, that the major deposits of oil found in the world today were developed. You can trace the path of the old Tethys Seaway by plotting the location of the major OPEC nation of the world. Stemming from the Gulf of Mexico, across to the Mediterranean Sea, the Persian Gulf and lastly into Indonesia, the warm tropical waters of the Tethys existed for millions of years.

Eventually, as the plates continued to move, Laurasia and Gondwana too began breaking up and moving in various directions. About 60 million years ago, India, actually on a different plate than Asia, slammed into the under portion of Asia, brought up sediment from the ocean floor, and created the Himalaya Mountains. (As a side note, India is still moving towards Asia which means the Himalayas are still growing). This explains how marine fossils were found at the base of the mountains.

When plates move, they are directly responsible for the occurrence of many different natural events, in addition to landformations. These all take place along plate boundaries, those areas where two or more plates lie adjacent to one another. As mentioned earlier, plate movement can be traced in three different directions, all specifically designed to create various natural occurrences.

The divergent plate boundary is the zone of separation between two tectonic plates moving directly apart from one another. Easily traced on land, this boundary is where rifts are located. The Great Rift Valley of east Africa is probably the most famous example. Beginning at the mouth of the Zambezi River as it empties into the Indian Ocean, you can follow the course of this valley through Lake Nyasa, Lake Tanganyika, Lake Albert, Lake Rudolf, through the Abyssinian Highlands of Ethiopia finally ending up in the Red Sea. Scientists predict that in another 50 million years, that portion of Africa, east of the rift, will completely separate forming an island.

Tracking a divergent plate boundary on the ocean floor is quite different. It wasn't until the development of sophisticated SONAR equipment that we began to understand how the process worked. Refered to as sea floor spreading, it is on the Atlantic Ocean floor we get the most comprehensive look at this happening. Along the center of the Mid- Atlantic Ridge, a section of the Mid- Oceanic Ridge, this sub-marine mountain system is literally coming apart at the seams. As it opens, magma from deep inside the earth wells up creating new land. Regardless of the fact that the island of Iceland is above sea level, it nevertheless is a portion of the Mid-Atlantic Ridge, thus giving us an excellant opportunity of observing just how sea floor spreading actually works.

In addition to rifts and sea floor spreading, volcanoes and earthquakes also occur along this plate boundary as well as others.

The transform fault plate boundary is the result of two tectonic plates sliding along the side of one another in opposite directions. The San Andreas fault of southern California is an excellant example. Moving in a northwesterly direction, it

has been estimated that within the next 50 million years, the site where the city of Los Angeles is located today will be located directly across from the site where San Francisco is located. It is along the transform fault boundaries many earthquakes originate.

If it is true that for every action there is an opposite and equal reaction, then the convergent plate boundary is the opposite of the divergent. Here we have two tectonic plates on a collission course. As the two collide, the smaller and weaker plate will be drawn beneath (subducted) the stronger one actually being absorbed into the mantle. As the stronger plate continues moving, it over-rides the weaker.

Depending upon the type of plate (oceanic or continental), a number of different formations result from this movement. When two continental plates collide, large mountain chains occur (i.e. the Himalayas).

When an oceanic and a continental plate collide, the continental plate over-rides the oceanic creating a mass of mountains of the continent and a deep trench on the ocean floor. A trench is a very deep valley located on the ocean floor along certain types of divergent plate boundaries. When the American and the Pacific plate collided, the Andes Mountains of South America and the Peru- Chile Trench along the west coast of the continent were created.

When two oceanic plates collide, island arcs and trenches are the result. An island arc is a chain of volcanic islands shaped in an arc pattern. The Mariana Islands and Trench are the result of such action. Being the deepest of all trenches, the Mariana is 36,198 feet deep. If that doesn't register, imagine placing Mt. Everest on the floor of the Mariana Trench and standing on it's summit. In order to break the surface of the sea, you would have to swim straight up over 1 mile. It is close to being 7 miles deep here.

As you can see now, many of the natural phenomena (volcanic eruptions, earthquakes, etc.) are the direct result of plate movement. The present day location of the plates, however, isn't the only place where we find fault movement or volcanic activity. This gives us the indication that perhaps old plate boundaries exist.

The whole process of the plates being together and splitting apart has happened before. Each time, brand new plates are formed. As proof of this, look to the geothermal activity of the Yellowstone National Park in Wyoming, or the New Madrid Fault in the central Mississippi River Valley. Add to that the fact that the underlying crust of the United States east of the Appalachian Mountains was at one time part of the African Plate.

At any rate, today there are six major tectonic plates and about a dozen smaller ones. The six major plates are:

-the American

-the Pacific

-the African

-the Eurasian

-the Indo- Australian

-the Antarctic

The dynamics of plate movement is still being examined carefully. At the present, the scientific community is leaning towards the existance of convection currents. Currents of heat from deep inside the earth come up towards the surface causing the plates to spread out.

By understanding this section on plate tectonics, the following portions pertaining to volcanoes and earthquakes should be easier to comprehend.

RELIEF FEATURES OF THE EARTH

As previously discussed in the section pertaining to landform characteristics, the topographic features of our earth are classified according to their relief. Our purpose here is to identify some of these formations and discuss their unique qualities. The scientific community, in their never ending quest to research and understand, use a technique whereby they sub-divide units into their component parts so that by closely examining each, they can understand the whole. So it is with landforms. As we look at the continents and the oceans basins, keep in mind the fact that no feature on the earth is permanent. Everything, no matter how large or small, is in a constant state of change.

'Oceans Basins'

The oceans basins cover approximately 71% of the earth's crustal surface. Upon close examination, there are three major divisions, or Second Order Relief Features, which must be recognized. The continental margin, or the zone of separation between the ocean floor and land is first. Let's imagine positioning ourselves in one of those minature submarines which is fully equipped with an area for viewing and lights which can be used as we travel below that point where sunlight is filtered out. As we make our voyage, we will begin to notice how very much different this "world" is in comparison to our own.

Extending out from the shore until a vertical depth of 600 feet is reached, our journey first takes us over the continental shelf. Actually an extension of the existing continent, the shelf is that area of the ocean where most marine life dwells. Here, sunlight can penetrate and stimulate plant growth through the process of photosynthesis. With the advent of plant growth, a food chain develops.

Moving beyond the shelf now, with our lights on, we observe an abrupt drop-off leading all the way down to the ocean floor. Known as the continental slope, this section of the margin is riddled with vertical gulleys called turbidity streams. Turbidity streams are caused by a very unique form of "underwater erosion." Beginning with a force which jolts the sediment of the continental shelf (earthquakes,

volcanic eruptions, or severe storms), mud is set in motion flowing down the slope. Over a period of many years, this mud carves out gulleys. Due to their density, these mudflows travel swiftly down the slope spreading out over the sea floor. In turn, the flows produce flat abyssal plains.

As our journey continues, the next region of interest is the second major division of the oceans basins, the ocean floor. It is here we will see the largest variety, as well as quantity, of landforms found anywhere on the earth. The uniqueness of this area is portrayed by the fact that certain features located here are synonymous only with this region. Guyots (geos) or seamounts, are flat-topped, submarine volcanoes. As lava is extruded from the volcano during an eruption, it comes into contact with the coolness of the oceans waters and cools into a "pillow" shaped formation. From this shape, we get the term pillow lava. Add to this the tremendous weight of the water from above and you can begin to see why the tops of these features are flat. As guyots grow in size, some eventually break surface and become full fledged volcanoes. For those which become extinct before, they simply add to the grandeur of the floors appearance.

Also found only on the floor are trenches or foredeeps. As discussed earlier, trenches are located along certain types of convergent plate boundaries where the one tectonic plates is subducted beneath the other. This zone of subduction forms the trench.

Island arcs are the floors last unique feature. Located next to trenches, they are formed as the dominant plate over-rides the weaker. This chain of volcanic islands is the location of many earthquakes.

As our journey through the oceans basins begins to come to an end, we now approach the very largest of all landforms located on the earth. The Mid- Oceanic Ridge, the last major division of the oceans basins, is a 40,000 mile long sub-marine mountain system with the tops of only a few of it's peaks visible. The Azores and Iceland are two such examples.

Representing a major fracture system of the earth's crust, the section of the Ridge located in the Atlantic Ocean is separating due to the process known as sea floor spreading. The Ridge extends from the Arctic area of central Asia over the North Polar region slicing it's way between Greenland and the Spitzenburg Islands. While cutting through Iceland, it winds it's way south through the Atlantic Ocean where it becomes part of the Mid-Atlantic Ridge. As it curls around the southern tip of Africa leading into the Indian Ocean, it travels through the Gulf of Aden where it connects with the Great Rift Valley of Africa.

While in the Indian Ocean, the Ridge splits to skirt Australia and New Zealand, zigzagging it's way through the Pacific Ocean on it's way towards California and Alaska. Needless to say, this is one unique system.

'Continents'

Like the oceans basins, the continents too can be divided into Second Order Relief Features, some of which are very noticeable (major) and some which are not (minor). The first major feature, the shield, is the oldest of all landforms. Remnants of ancient mountain chains, shields have been worn down over hundreds of millions of years of weathering and erosion. All thats left of these features is the base. The base is mainly composed of metamorphic rock due to the tremendous amount of time, heat and pressure it has been subjected too.

Mountains are very large expanses of areas which exhibit a relief of over 2,000 feet and are the direct result of tectonic activity. Upon close examination, this activity is the work of three different processes: folding, faulting and volcanism. Folded mountains are the result of the earth's crust being buckled by tectonic activity. A series of anticlines (upfolds in the earths crust) and synclines (downfolds or troughs in the earth's crust) occur. Mountains are parallel with a system of valleys in between. The Appalachian, Rockies, Swiss Alps, Atlas, and Himalayas are all folded.

Faulting occurs over a period of millions of years where there is a vertical

displacement of land along a fault line. The Sierra Nevada Mountains of eastern California are faulted.

Volcanoes, the last major mountain building process, will be discussed in detail in the next section. They are individual mountains located along plate boundaries.

Hills, another major landformation, can generally be catagorized into 2 classes according to their relief. Those areas which exhibit a relief of 1,000-2,000 feet are classified as high hills, low mountains or foothills. Those with a relief in between 300-1,000 feet are simply hills.

The last two major landforms, plains and plateaus, are very similar in the respect that plateaus are actually elevated plains which sharply rise above the countryside on at least one side. Plains, on the other hand, have a lower elevation. Showing a relief ranging from 0-300 feet, these formations cover large expanses of land and are excellant sites for population settlement and agriculture in the proper latitudes.

Minor landforms are those landforms which, through the erosional and weathering forces of our atmosphere, have cut through the major formations just mentioned. The following is a list along with their definitions:

-valley any area which is drained by it's rivers and their tributaries.

-canyon steep walled valleys.

-ravine small canyons

-gorge narrow, steep walled canyon

As you can see, we have just covered the gambit of the earth's more prominant topographical features. While smaller ones do exist, your understanding of the ones discussed and their formation provides a good basis for future study.

VOLCANOES

Whenever we hear the term "natural disaster", we automatically envision a calamity involving the loss of many lives. How we arrive at such a concept basically has historical roots which dates back thousands of years having been passed down from generation to generation either verbally or in written form. The question, however, revolves around the specific term "disaster." By whose concepts are these natural occurrences disaterous? Does the fact that man continues developing entire complexes on fault lines, at the base of volcanoes, or on the flood plains of rivers give him the right to determine what is or isn't disasterous? Consider one thing before passing judgement here. Regardless of it's magnitude, no natural occurrence happens for no reason at all. There is a rhyme and reason for everything. Whether or not man is capable of understanding these reasons is the real question. Out of the ruins of adversity, nature generally gives us something positive to work with.

For many years, the awesome powers of nature were viewed as the acts of gods, or the result of some superstitious belief. This inability to understand could easily be explained by placing the blame on some supernatural power beyond our ability to comprehend. Volcanic eruptions are prime examples. Volcanoes are individual mountains generally located along plate boundaries built by volcanic debris extruded from the earth. This debris is classified according to it's consistency and the size of it's particles. Magma, molten rock material located within the earth, is hotter and more fluid than lava. Lava is what magma becomes once it reaches the earth's surface and is exposed to the atmosphere. At this point it begins to cool and solidify. Obviously warmer and more fluid at it's source, lava travels swiftly down the slope of a volcano only to slow up as it moves on to somewhat level ground. As it cools, lava from behind begins to flow on top of it, thus increasing it's thickness.

Along with lava, some volcanoes are noted for releasing what volcanologists call

volcanic bombs. These flaming boulders, sometimes weighing a ton or more, are hurled through the air as the volcano explodes. It doesn't take much imagination to visualize the amount of damage which is possible as these objects strike the earth.

In descending order, according to size, volcanic cinders, volvanic ash, and volcanic dust are also issued from these volatile mountains. Cinders, like firey projectiles, rain down upon the country side around volcanoes. Two to three inches in diameter, these are quite a nemesis to the animal life of the region.

Ashes, due to their light weight, eventually blanket the area after the cinders have fallen. As the volcano continues to erupt, several feet of ash could cover the landscape, giving it a very desolate appearance.

Volcanic dust, on the other hand, generally ends up in the upper atmosphere as it is carried by the prevailing winds. In many instances, volcanic eruptions which occur in remote regions of the earth are not detected until a weather satellite picks up the volcanic dust on film or a weather radar unit charts it's path as it travels over heavily populated regions.

Perhaps far more devastating to existing life, however, moreso than volcanic bombs, cinders or lava, is what is known as a nuée ardente. Commonly refered to as Pelean Clouds, these clouds of super heated steam and ash roar down the steep slopes of volcanoes at speeds in excess of 100 miles per hour literally burning or disintigrating anything in its path. The two classic examples of this can be witnessed by accounts depicting what happened to the city of St. Pierre on the Caribbean island of Martinique after Mt Pele erupted in 1902, and the archeological excavation of the sites of Pompeii and Herculaneum after Mt. Vesuvius erupted on the 24th of August, 79 A.D. The utter destruction caused by these clouds is mind boggling.

Lastly, poisonous gases can be emitted by some volcanoes. As a precaution, when volcanologists examine active volcanoes in their attempt to learn more about them, gas masks are worn. There are enough problems to deal with on these treacherous slopes without having to worry about the gases all around you as well.

'Classifications of Volcanoes'

If asked to picture in your mind's eye what a volcano should look like, a majestic cone shaped peak, perhaps like that of Mt. Fujiyama of Japan, might come to mind. Not all are cone shaped, however. Some, like the humps of a camels back, are dome shaped and exhibit a different set of characteristics. The differences lie in the force of the eruption and the debris being extruded. At this point, let's take some time to differentiate between those volcanoes which "erupt" and those which "explode."

On the 27th day of August, in the year 1883, Mt. Krakatoa, a composite cone volcano located in the Sunda Strait between the islands of Sumatra and Bandung, exploded with such a force that it produced the loudest noise and perhaps the most violent explosion this world has ever witnessed. This climactic end was the result of the earth's crust splitting open at the base of the volcano allowing sea water to pour in, thus mixing with the white hot interior of the planet. Volcanic bombs were shot upward into the atmosphere 25 miles. Sound waves knocked over trees and houses within a 100 mile radius of the island. Ear drums burst from the noise as far as 350 miles away. The actual noise from the volcano was heard on the Indian Ocean island of Rodriguez, some 3000 miles away. Massive seismic sea wave destroyed villages, docks and ships all the way to Japan. Rounding Cape Horn, these sea waves made their way to the English Channel where they cause some disturbance. Volcanic dust encircled the globe and remained in the atmosphere for a year afterwards. After all was said and done, 36,000 lives had been lost, 300 Indonesian villages were demolished, 6,000 ships had been destroyed, and two-thirds of the island of Krakatoa had literally been blown to pieces. As is quite apparent from this account, explosive volcanoes are very dangerous when active and should be observed with great caution from a safe distance. Other explosive volcanoes of note are, Mt. St. Helens, Mt. Vesuvius, and Mt. Etna.

On the opposite end of the pendulum, we find those volcanoes which erupt. Instead of getting as far away as possible when these mountains become active, people flock to watch natures most spectacular display of fireworks. Lava usually bubbles up and pours over the rim of the crater. Volcanic cinders shoot out raining down upon the slopes and surrounding countryside. The islands of Hawaii are examples of such volcanoes. Aside from it's obvious exotic beauty, much of the Hawaiian tourist industry is based upon the fact that these volcanoes, when erupting, can be observed in the general area with a limited amount of risk. Due to our inquisitive nature, if presented with the opportunity of observing first hand the eruption of a volcano, most of us would jump at the chance of seeing one of natures awesome powers at work.

In reference to the Hawaiian Islands, the formation of these volcanoes did not take place in the usual fashion along plate boundaries. Instead, these unique islands are the result of what scientists call hot spots. Appearing in a fixed position, a hole in the crust of the earth allows magma from the mantle to well up in the form of a mantle plume. As the plates move over this mantle plume, a mass of lava comes out forming a volcano. At present, the active volcano of Kilauea is directly over this hot spot. As the Pacific plate continues moving in a northwesterly direction, newer seamounts (guyots), which could eventually become islands, will be added to this group.

Getting back to the task at hand, volcances can also be classified according to their activity. Active volcanoes are those which are currently erupting or have done so over the past several years. Historically, a chronological record has been kept dating these events. By studying the frequency of activity, scientists can determine if there is a pattern to the eruptions. If there is, and the pattern is disrupted by inactivity, volcanoes enter a dormant state. Most, however, follow a pattern which weaves in and out of the active-dormant cycle.

As with all landforms, there comes a point in time when growth ceases. When volcanoes stop erupting, their activity being completely over, they are said to be

extinct. Extinct volcanoes give volcanologists an excellent opportunity to study these natural phenomenons and the effect they have on their environments.

Varying in the composition of the lava and the nature of their size, volcanoes fall into four basic catagories. Cinder cones are the smallest of the volcanoes. Having very steep sides, the cones themselves consist of ash and cinders cemented with lava over a period of time. Being that size is somewhat deceiving at times, these are highly explosive volcanoes with the capability of producing very thick lava flows, up to 13 feet in some instances. In the United States, cinder cones can be found in New Mexico and other sections of the southwest.

Composite cones, also known as strato volcanoes, are the largest of the cone shaped volcanoes as well as the most highly explosive. Being that most of the world's volcanoes are of this variety, it is also true that most of the major eruptions which have occurred are from composite cones. In the United States, we find these in the Cascade Range of Oregon and Washington.

Shield volcanoes are the dome shaped mountains which are quite different in character from the cone shaped peaks. The largest of the volcanoes, these generally produce a more fluid, thus thinner lava flow. As the lava solidifies and erodes over a span of time, some of the world's richest soils are produced. By comparison, shields are relatively quiet when they erupt. The Hawaiian Islands are shield volcanoes.

Very closely related to the shields are lava domes. Noted, however, for extruding Pelean clouds, these mountains pose a definitive threat to all life in the immediate area.

'Location of Volcanoes'

As we look around the earth to where the vast majority of the volcanic peaks are located, we soon realize that a pattern circumnavigates the Pacific Ocean. Refered to as the Pacific Ring of Fire or the Circumpacific Rim, the mass quantity is caused by the movement of the Pacific plate in relation to the others it comes in contact with. The mountainous west coasts of North and South America, the islands of Indo-

nesia and Japan, and the islands of the south Pacific all lie along this belt of volcanic activity.

Secondary zones of volcanic activity can be found in the region of the Mediterranean Sea which encompasses the Middle East as well. Also included are the islands of the Carribbean.

'Volcanic Formations'

Interestingly enough, nature doesn't always create the perfect design. If the sides of a volcano are not steep enough and a violent eruption occurs, the top of the peak could collapse creating an unusually large crater. This is refered to as a caldera. A perfect example of this is Mt. Masama, located in the state of Oregon. Commonly refered to as Crater Lake, the size of the existing crater gives you an idea of how large these formations can get.

Over the eons of time, volcanoes give in to the rigors of erosion and weathering. Hard spirals of rock extruding from what was once the crater become the only thing left of these former majestic mountains. These spirals are known as volcanic knecks.

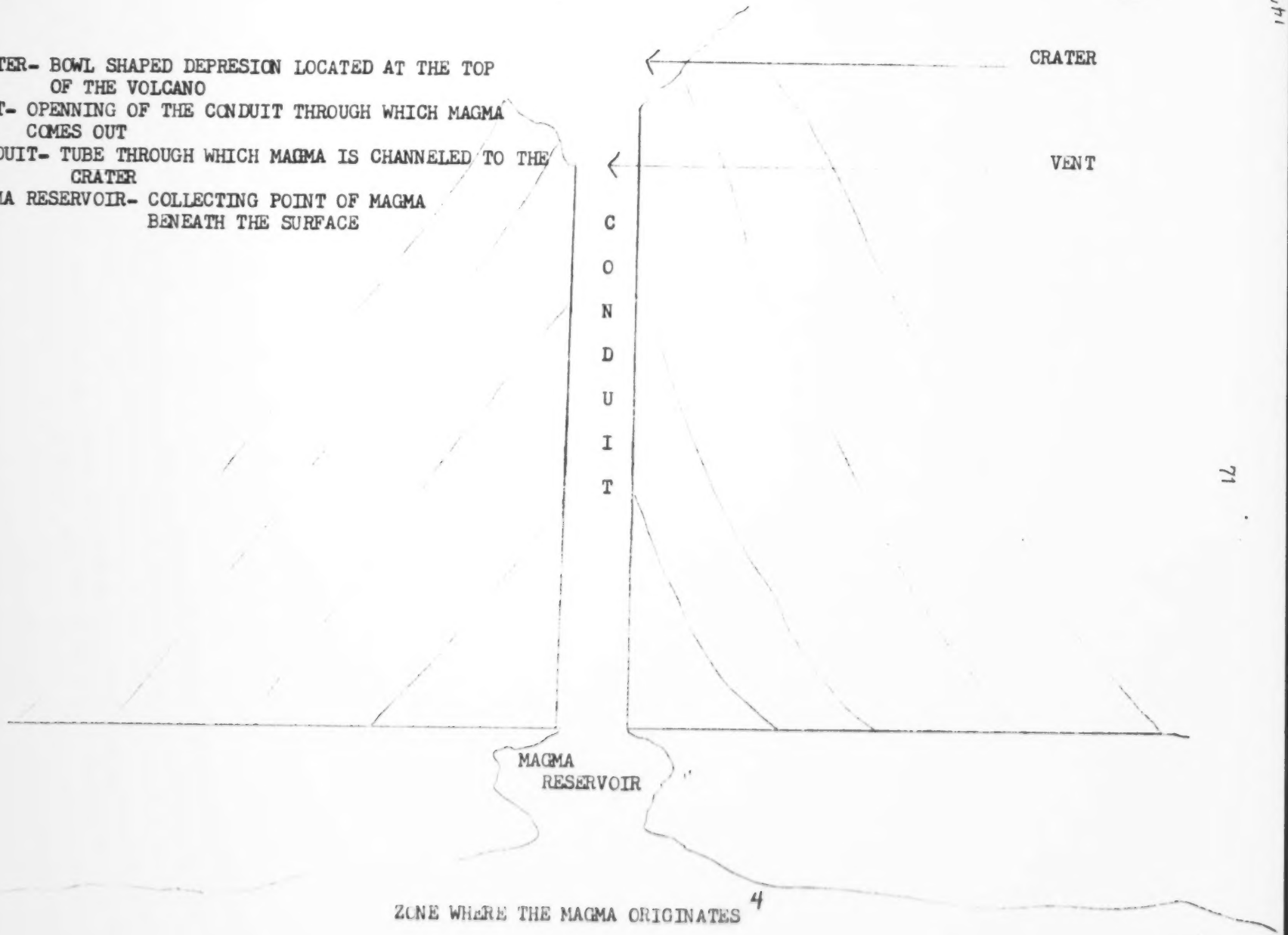
One of the common misconceptions many people have is that lava comes only from volcanoes. This simply isn't true. Sometimes lava comes out of the ground in an area which is not associated with volcanoes. The Columbian Plateau, one such area, is a vast outpouring of lava over 1 mile thick in some places. Rivers, which have cut through this region, have produced a very rugged landscape.

CRATER- BOWL SHAPED DEPRESION LOCATED AT THE TOP OF THE VOLCANO

VENT- OPENNING OF THE CONDUIT THROUGH WHICH MAGMA COMES OUT

CONDUIT- TUBE THROUGH WHICH MAGMA IS CHANNELED TO THE CRATER

MAGMA RESERVOIR- COLLECTING POINT OF MAGMA BENEATH THE SURFACE



EARTHQUAKES

Throughout the centuries, man has pondered not only his own existance, but also that of his natural environments, both physical and biological. In our attempts to understand certain events which have proven not only puzzling, but also frightening, we directed our attention to those select groups of people whose knowledge was highly respected. Feeling pressure to come up with logical solutions, much thought was given to the questions at hand. Keep in mind, as previously mentioned, the total accumulation of information about our natural world was somewhat lacking, thus accounting for many of their responses being totally unfounded. Short as they may be, let's examine two such explanations as to the occurrences of earthquakes.

Aristotle, an extremely well known Greek philosopher, explained this sometimes rather violent movement of the earth's crust as being the result of entrapped air escaping from the earth's interior. His was a natural explanation. Some theologians around 2,000 years ago, however, taught that all earthquakes were manifestations of God's wrath. Given the mobility of the earth's population at that time, people ascribing to this explanation and living in earthquake prone areas must have lived a life of guilt, constantly striving to better themselves.

Today, having been ushered into an era of scientific enlightenment, we now know how very wrong these early explanations were. Earthquakes, the natural vibrations of the earth produced by a rupture of large masses of rock beneath the crustal surface, are the result of plate movement. As stated earlier, tectonic plates move approximately 1-3 centimeters per year. Due to intense stress, if there is a sudden slippage of rock focusing deep beneath the surface, shockwaves are released in a 360 degree radius from that point of origin, otherwise known as the focus. (That point straight up from the focus on the earth's surface is called the epicenter) Those waves which follow the contour of the earth's surface are what we refer to as earthquakes.

The intensity of the quake depends greatly upon the depth of the focus. As we begin to examine this area, we will discover three distinct depths in which earthquakes originate. Briefly, the shallow zone lies between 0-40 miles beneath the earth's surface and is the location of a majority of the earth's devestating earthquakes.

The intermediate zone is situated between 40-200 miles beneath the earth's surface and is the location of only a few noticable quakes.

Finally, the deep focus is situated between 200-500 miles beneath the earth's surface. It is here that a majority of the earth's quake movement takes place, but is never felt.

'Measurement of Earthquakes'

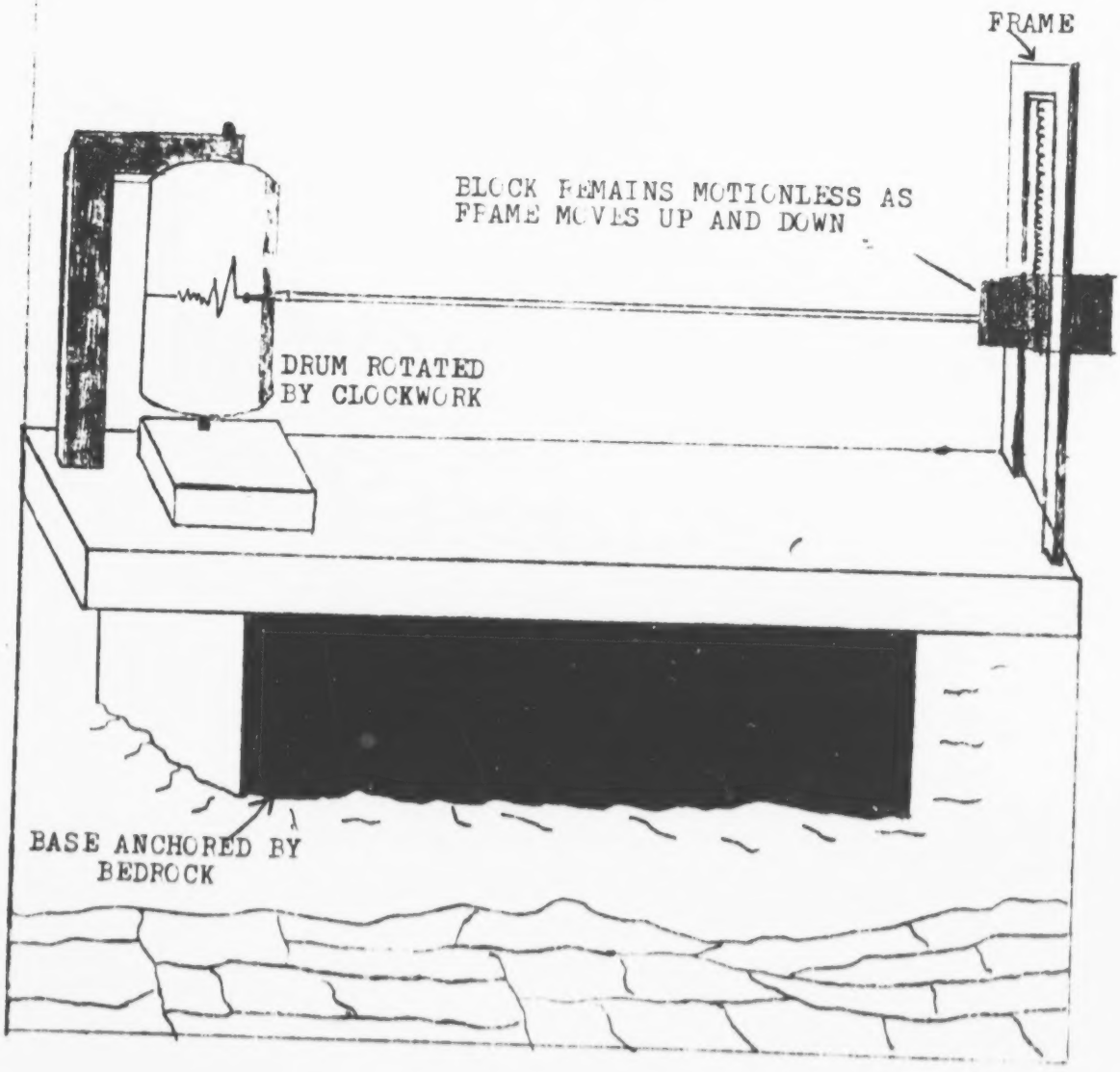
To the science of seismology (the scientific study of earthquakes), the development of the seismograph was a tremendous breakthrough in the understanding of earthquakes. Not only was it responsible for our conception of the earth's interior, it also allowed the scientific community a chance to isolate specific regions of the world prone to quake activity thus enhancing their studies. The ultimate goal is to predict quake movement before it actually happens.

Operating off of the principle that all objects at rest will remain at rest, the seismograph is a pendulum devise which records the time and the intensity of the actual motion of the earth during a quake. The graphic record produced by the seismograph is called a seismogram. As with all graphs, there must be a scale from which the recordings are based. The scale of numbers recorded on a seismogram is called the Richter Scale. Developed by Dr. Charles Richter, this method is a scale by which earth tremors are measured according to their intensity. The scale ranges in numbers from 1 through 9 with each whole number 10 times greater in intensity than the number before. This is our most commonly used method of measuring the forcefulness of the shockwaves.

Another method used in the United States to measure the intensity of earthquakes centers not on actual earth movement, but instead on how much damage is done to the

BASIC PRINCIPLE OF THE SEISMOGRAPH:

ALL OBJECTS AT REST WILL REMAIN AT REST [5]



(5)

MODIFIED MERCALLI INTENSITY SCALE[6]

I. Not felt except by a very few people under especially favorable circumstances.

II. Felt indoors only by a few persons, especially on the upper floors of buildings. Delicately suspended objects may swing.

III. Felt quite noticeably indoors, especially on the upper floors of buildings. Vibrations are like the passing of a truck.

IV. Felt indoors by many, outdoors by a few. Dishes, windows, doors disturbed; walls make a creaking sound. Sensation like a heavy truck striking a building.

V. Felt by nearly everyone, many awakened. Some dishes, windows, etc. broken. Small objects move; furnishings may shift.

VI. Felt by all, many frightened and some run outdoors. People move unsteadily. Damage is slight.

VII. Everybody runs outdoors; frightens everyone. Damage is negligible in buildings of good design and construction; slight to moderate in well built structures; considerable in poorly built or badly designed structures; some chimneys broken.

VIII. Alarm approaches panic. Damage is slight is specially designed structures; considerable in substantial buildings with partial collapse; great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud erupts in small amounts.

IX. Damage considerable in specially designed structures; great in substantial buildings, with partial collapse; buildings shifted off foundations. Ground cracked conspicuously. Underground pipes sometimes broken.

X. Some well built wooden structures destroyed; most masonary and frame structures destroyed. Railroad rails bent. Landslides considerable from riverbanks and steep slopes. Shifted sand and mud. Water splashes over banks.

XI. Few if any structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines are completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown up in the air.

earth and property. Refered to as the Modified Mercalli Intensity Scale, the numbers used in this method range from 1 through 12 with 12 being the most devastating.

'Faults'

Faults are cracks in the brittle crustal surface of the earth along which movement has taken place. This movement is the result of a slippage or displacement of rock along the plane of breakage. It has been through intense studies that we have come to recognize 4 different types of faults where earthquakes occur. As we begin to describe the characteristic movement of each fault, it will become quite apparent that some are more complex than others.

The movement of a normal fault is in a vertical direction in that one side of the fault is thrown up while the other side is cast down. The result is a steep straight fault scarp (that point where the fault actually intersects with the earth's surface) whose height is an approximate measurement of the vertical element of displacement.

Exhibiting very similar characteristics to that of a normal fault is a reverse fault. While it is true that the movement displayed here is vertical, the angle of inclination of that side being thrown up is such that landslides are quite possible, if not probable.

Entering into the horizontal realm of fault movement, we now have the transcurrent or transform fault. Coinciding directly with the plate boundary of the same name, here we have two side of a fault literally sliding by one another. If a stream cuts across such a fault and movement takes place, it is not uncommon to find a 90 degree bend in the stream bed as the stream turned to follow the fault for a short distance.

The final and perhaps the most difficult fault to describe is the low angle overthrust fault. Try and imagine a combination of the three previously mentioned faults all rolled into one. While it is true that the movement here is predominently horizontal, one side of the fault actually overrides the adjacent side. This is

made possible by the fault plane being horizontal. The result is a very irregular fault scarp.

'Major Historic Earthquakes'

"The New Madrid Quakes"

Prior to the invention of the seismograph and the Richter scale, the only way the intensity of earthquakes could be determined was by first-hand accounts. It was from this method that knowledge of perhaps the most powerful earthquakes ever to strike the North American continent was passed down to future generations. On December 11, 1811, January 23, 1812 and February 7, 1812 three massive quakes shook the central section of the Mississippi River Valley around what is now New Madrid, Missouri. So powerful were the quakes, the effects were felt as far away as New Orleans, Louisiana and Washington D.C. In the immediate area, ceaseless tremors continued for a year afterwards and intermittent ones for the next seven. Scientists predict that had the Richter scale been developed at this time, each quake would have registered well over an 8.5.

"The San Fransisco Earthquake"

Probably the most famous earthquake ever recorded in the United States was the one which took place on April 18, 1906 in the city of San Fransisco, California. With an estimated Richter reading of over an 8, one would have thought that the bulk of the damage would have been caused by the tremors themselves. Oddly enough, only about 5% of the estimated 400 million dollar loss was directly attributed to them. In 1906, many people used fuel oil or kerosene for cooking and lighting. When the quake struck, fires were set all over the city. With water mains being disrupted by the tremors, fire fighters had to sit back helplessly and watch the city burn.

"Alaskan Earthquake"

On March 27, 1964, a devastating earthquake centered around Anchorage, Alaska made it's presence known. The quake itself was felt as far away as Juneau, to the south, and Fairbanks, to the north. Registering an 8.6 on the Richter scale, it

was estimated to have released twice as much energy as the San Fransisco quake of 1906. Reported to have been felt over a 500,000 square mile area, it triggered large scale avalanches and landslides. Tsunami's (seismic sea waves) 40 feet tall in some cases, were recorded as far away as Japan, Hawaii and southern California. With the focus located just 12 miles beneath the earth's surface, the vertical displacement along the fault scarp was 30 feet. Ironically, March 27 of 1964 happened to be Good Friday.

GLACIERS

The mere mention of the term glacier usually brings to mind that of a large mass of moving ice which has a definite affect upon the alteration of a regions landscape. Like huge bulldozers with their blades down, the ice scrapes and cuts as it passes over the earth's surface. Occurring naturally in both the high altitudes and latitudes, glaciers are found in three distinct forms all developing in accordance with their location. The purpose of this section is to identify each glacial type and the landformations, if any, associated with each.

'Alpine Glaciation' (Mountain or Valley Glaciers)

When heavy snowfall continues to accumulate in the upper elevations of a mountainous region, remaining there for an extended period of time, it's weight causes the compaction of snow having fallen from previous years. This weight transforms the "old" snow into grandular particles of ice called firn. Over the years, as the firn is gradually changed into a solid sheet of ice, the weight of the snow at it's point of origin, coupled with gravity, begins to pull the mass of ice down the slope of the mountain. Usually following an old stream valley, the glacier will continue moving forward as long as the rate of accumulation in the upper altitudes exceeds the rate of melting in the lower. As the glacier progresses to an elevation where the temperatures are warm enough to exceed accumulation, advancement will eventually stop.

When the glacier moves through a valley, it re-molds the region into a U-shaped glacial trough thus creating an entirely new topographical profile. With the obvious force of ice erosion at work here, the following is a list of erosional and depositional landforms created directly by alpine glaciation.

"Erosional Landforms"

1. Glacial Trough- the U-shaped valley cut by the erosional forces of an alpine glacier.
2. Cirque- a bowl shaped depression at the head of a glacial valley.
3. Tarn- round lakes created in cirques (cirque lakes)

4. Arete- the narrow saw-toothed ridge created when 2 alpine glaciers erode the side of a mountain.

5. Horn- the remaining isolated peak created when 3 or more glaciers erode the side of a mountain.

6. Col- A pass or low place through an Arete.

7. Hanging Valley- the valley formed when a tributary glacier at a higher elevation meets the main glacier. Today they are the sites of waterfalls.

8. Truncated Spur- the cut off portion of a mountain side.

9. Glacial (Rock) Step- due to the fact that ice does not erode smoothly, the bottoms of glaciers are sometimes irregular creating steps on the valley floor.

10. Trough Lakes- an elongated lake occupying an old glacial step.

11. Fiord- a deep, steep sided canyon like feature cut into a mountainous coastline by an alpine glacier as it advances towards the sea.

"Depositional Landforms"

1. Moraines- a ridge of material (till) deposited by the glacier.

2. Lateral Moraine- a ridge of till deposited along the side of a glacial trough

3. Medial Moraine- as two glaciers come together, the inside lateral moraine of both merge forming a centerally located ridge of till.

4. Terminal Moraine- glacial till found at the lower end of a glacier. Marks the farthest advancement of the ice.

5. Recessional Moraine- new moraine deposited across the valley floor during a period when the retreat of the glacier stopped.

'Continental Glaciation'

In those areas of the earth where the total accumulation of snow during the winter exceeds that which melts during the summer, a different type of glacier begins to form. Originating in the high latitudes, these ice sheets move over extremely large areas, not as the result of gravity, but due to pressure originating in the middle creating a movement outward in a radial fashion. Whereas alpine glaciers have the potential of moving several hundred feet during the course of a year (depending upon the slope and terrain), continental ice sheets move much slower usually smoothing out the landscapes they pass over. The following is a list of depositional features

usually associated with continental glaciers.

1. Moraine- a ridge of glacial till deposited by the ice

2. Terminal Moraine- glacial till found at the lower end of a glacier. Marks the farthest advancement of the ice.

3. Recessional Moraine- till deposited as the result of a temporary pause and re-advancement of the ice during a cold spell.

4. Interlobate Moraine- deposits of till separating the lobes of ice created by the ice sheet.

5. Till Plain- a large area covered with glacial till

6. Drumlin- a hill shaped like a ½ egg cut lengthwise with the elongated axis always parallel to the direction of the ice flow.

7. Esker- a long ridge of sediment many miles long but only a few feet wide deposited by water instead of ice. Forms as a result of a river under the ice.

8. Kame- a ridge mass of glacial till with no particular shape or orientation.

9. Outwash plain- a large or wide plain of sediment deposited by the glacier as it melts.

10. Valley Train- Glacial outwash deposited in a small stream.

11. Kettle- a pond created by glaciers. Located in ouwash plains and moraines, as large chunks of ice break off from the glacier and are carried by the meltwater, they become surrounded by outwash before they melt. As the ground above caves in, ponds are formed.

12. Ice Marginal Lakes- a lake located out in front of the outer edge of a glacier. Formed as a river is blocked by the forward advancement of the glacier.

13. Glacial Erratic- rock found in glacial till which is foreign to the area in which it is found.

14. Ice Bergs- large chunks of glacial ice (frozen freshwater) floating in the oceans

'Piedmont Glaciation'

Piedmont glaciers are very rare in that a specific set of circumstances must exist before such a formation can develop. If the snout of an alpine (valley) glacier spreads out into a bulbous form, or if the snouts of several alpine glaciers coalesce into a single broad mass, piedmonts form. As you can imagine, this does not happen often.

Questions for Assistance

Characteristics of Landforms-The Interior Structure of the Earth

1. _____ are any of the physical or inorganic features of the Earth which have relief and are formed naturally.

2. List and define the 3 characteristics all landforms have in common.

3. How have scientists determined what the internal structure of the Earth consists of?

4. Distinguish the difference between liquid and solid as it applies to the Earth's interior. What determines the difference between the two?

5. Beginning with the innermost concentric layer of the Earth's interior and progressing towards the surface, list each section of the Earth's interior structure and tell whether it is a liquid or solid.

6. What is the Moho Discontinuity?

Questions for Assistance

Plate Tectonics

1. Who was Alfred Wegener and how was he instrumental in the development of the now accepted theory of Plate Tectonics?

2. Certain pieces of evidence, which first began as questions, are at present confirming the movement of the tectonic plates. List these as presented in the text.

3. Define the following term as they apply to Plate Tectonics:
   a. rift
   b. sea floor spreading
   c. subduction
   d. trench
   e. island arc
   f. convection currents

4. Complete the following:

About 200 million years ago, all of the continents of the world were joined forming one giant super continent known as _____. Soon after, _____ separated into two sections creating two large continents with a body of water in between. The northern continent became known as _____ while the southern was called _____. The _____ Seaway separated the two. It was the _____ Seaway in which most of the world's oil deposits were formed.

Before the break up of this giant continent, the ocean which surrounded it was called _____, which means "all seas". This was also the ancestoral Pacific Ocean.

The large continent to the north consisted of the modern day continents of _____, _____, and _____. To the south, that continent consisted of _____, _____, _____, _____, and _____.

Today, we know the plates are responsible for the geologic formations of volcanoes and earthquakes. These generally occur along new or old plate boundaries. In reference to plate boundaries, the boundary in which two tectonic plates are actually moving apart from one another is called a _____ Plate Boundary. This creates rifts on land and sea floor spreading on the ocean floor. Volcanoes and deep valley are also found along these boundaries.

When two tectonic plates are moving towards one another actually on a collission course, _____ Plate Boundaries form. These are responsible for the formation of island arcs, trenches, mountains volcanoes, and earthquakes as well.

Finally, when two tectonic plates are sliding past one another, a _____ Plate Boundary forms. The most famous fault of this nature is the _____ _____ Fault of southern California.

Questions for Assistance

Relief Features of the Earth-Volcanoes

1. The Second Order Relief Features of the Oceans Basins can be divided into 3 major sections. List them:

2. Define the following as they apply to the Oceans Basins:
   a. continental shelf
   b. continental slope
   c. turbidity streams
   d. abyssal plains
   e. guyots
   f. pillow lava

3. Continents, too can be divided into second order relief features. List these major relief features and define the major landforms which are found in these catagories.

4. List and define the 4 minor landforms of the Earth.

5. What are volcanoes and where do most of these natural phenomenons occur?

6. Distinguish between magma and lava.

7. Define the following types of debris issued from volcanoes during eruptions:
   a. volcanic bombs
   b. volcanic cinders
   c. volcanic ash
   d. volcanic dust
   e. nuee ardente or Pelean Clouds

8. Distinguish between those volcanoes which erupt and those which explode.

9. Not all volcanoes develop along plate boundaries. Some are created over what scientists call "hot spots." Describe these areas.

10. List the 3 different stages of volcanic activity.

11. Volcanoes can also be catagorized according to their shape and size. List the 4 different types of volcanoes using this criteria.

12. What is the Pacific Ring of Fire?

13. What are calderas and volcanic knecks?

14. Define the following:
   a. crater
   b. vent
   c. conduit
   d. magma reservoir

Questions for Assistance

Earthquakes

1. The natural vibrations of the Earth produced by a rupture of large masses of rock beneath it's surface resulting from a movement of the tectonic plates are called _____.

2. Distinguish between focus and epicenter.

3. Earthquake intensity, to a large extent, dependes upon the depth of the focus. Identify the 3 distinct zones of focus along with their depth below the Earth's surface.

4. Identify the following:
   a. seismology
   b. seismograph
   c. seismogram
   d. Dr. Charles Richter
   e. Richter Scale
   f. Modified Mercalli Intensity Scale

5. Cracks in the brittle surface of the Earth along which movement has taken place are called _____.

6. List and describe the four different types of faults along which earthquakes occur.

Questions for Assistance

Glaciers

Match the following definitions with the word list on the following page to assist you in completing the word search puzzle.

1. The U-shaped valley cut by the erosional forces of an alpine glacier is called a _____.

2. Round lakes created by cirques are called _____.

3. The remaining isolated peak created when 3 or more glaciers erode the side of a mountain is called a _____

4. A valley formed when a tributary glacier at a higher elevation meets the main glacier is called a _____. Today these are the site of many waterfalls.

5. Due to the fact that ice does not erode smoothly, the bottoms of glaciers are sometimes irregular creating steps on the valley floor. These formations are known as _____.

6. A deep, steep sided canyon like feature cut into a mountainous coastline by an alpine glacier as it advances towards the sea is called a _____.

7. A ridge of till deposited along the side of a glacial trough is called _____ moraine.

8. The glacial till located at the lower end of a glacier is called _____ moraine.

9. A bowl shaped depression located at the head of a glacial valley is called a cirque.

10. A narrow saw-toothed ridge created when 2 alpine glaciers erode the side of a mountain is called an _____.

11. The pass, or low place through an arete is called a _____.

12. The cut off portion of a mountain side is called a _____.

13. An elongated lake occupying an old glacial step is called a _____.

14. A ridge of material (till) deposited by a glacier is called _____.

15. As two glaciers flow together, the inside lateral moraines of both merge forming a centerally located ridge of till known as a _____ moraine.

16. New moraine deposited across the valley floor during a period when the retreat of a glacier stopped is known as _____ moraine

17. A large mass of moving ice is called a _____.

18. Grandular particles of ice caused by the weight of new snow and ice is called _____.

19. Another term describing a mountain glacier is an _____ glacier.

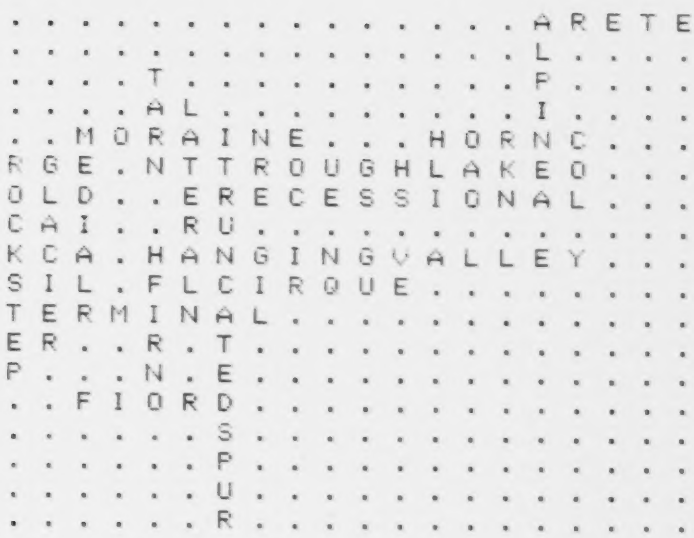
ALPINE GLACIATION

S B V E Q M R B C N Z S I C H A R E T E
I N U X P Z S R B M L N E P J L P R Q W
V P R I T L Z Q L P M N I O Q P D V F J
U G I B A L N Y Y X B Y O W O I G S D O
M N M Q R A I N E I Y H H Q R N C J J X
R G E I N T T R O U G H L A K E O S D A
O L D J K E R E C E S S I O N A L Z Z C
C A I J U R U V M Q E M J X I L C Y W T
K C A U H A N G I N G V A L L E Y I M D
S I L V F L C I R Q U E S E D G T D I W
T E R M I N A L C P Z Y J F L G B A S U
E R J U R B T T N B Q P V R X Z H D L L
P K R E N Q E Q R X D T P R O B Z O V U
X G I I U K D X Z A R X W B T T X R G X
U I Y Z W C S T Z M K W K U H R E P P R
U X Y T Y I P C V P F E J P B Y A U W B
K J B T Q C U T Q C C V A K Z E G Y Y Z
F X G H W R R L D Q U M Y X C S T V Z P

Can you find these words?

TRUNCATEDSPUR
TROUGHLAKE
LATERAL
ALPINE
TROUGH
HORN
COL
HANGINGVALLEY
TERMINAL
MORAINE
MEDIAL
FIORD
TARN
RECESSIONAL
ROCKSTEP
GLACIER
CIRQUE
ARETE
FIRN

Answer Key for: ALPINE GLACIATION


. . . . . A R E T E
. . . . . L . . . .
. . . . T . . . . . P . . . .
. . . . A L . . . . . I . . . .
. . M O R A I N E . . . H O R N C . . .
R G E . N T T R O U G H L A K E O . . .
O L D . . E R E C E S S I O N A L . . .
C A I . . R U . . . . . .
K C A . H A N G I N G V A L L E Y . . .
S I L . F L C I R Q U E . . . . . .
T E R M I N A L . . . . . .
E R . . R . T . . . . . .
P . . . N . E . . . . . .
. . F I O R D . . . . . .
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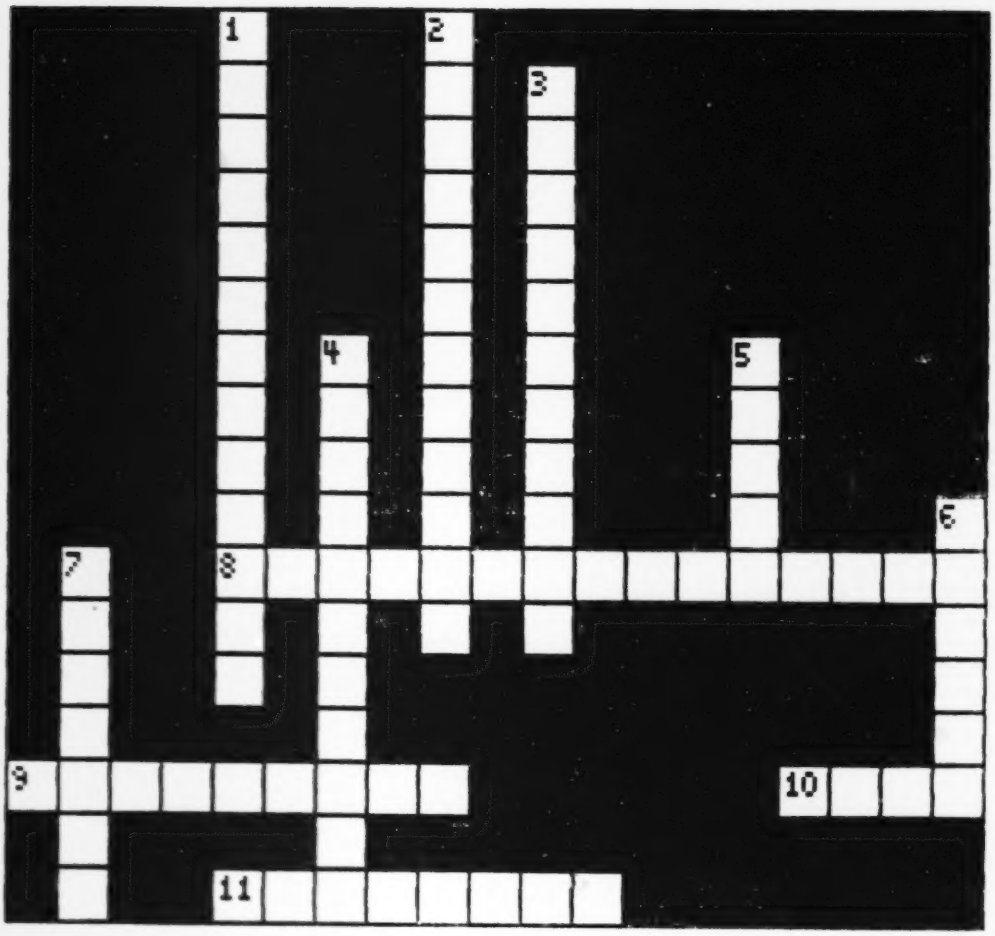

CONTINENTAL GLACIATION

ACROSS:

8. GLACIAL TILL FOUND AT THE LOWER END OF A GLACIER
9. A LARGE AREA COVERED WITH GLACIAL TILL
10. A RIDGE MASS OF GLACIAL TILL WITH NO PARTICULAR SHAPE OR ORIENTATION
11. LARGE CHUNCKS OF GLACIAL ICE FLOATING IN THE OCEAN

DOWN:

1. ROCK FOUND IN GLACIAL TILLWHICH IS FOREIGN TO THE AREA IN WHICH IT IS FOUND
2. A LARGE OR WIDE PLAIN OF SEDIMENT DEPOSITED BY THE MELTWATER OF A GLACIER
3. MORAINE DEPOSITED AS A RESULT OF A TEMPORARY PAUSE AND RE-ADVANCEMENT OF THE ICE
4. A MORAINE SEPARATING LOBES OF ICE CREATED BY THE ICE SHEET
5. A LONG NARROW RIDGE OF SEDIMENT DEPOSITED BY THE MELTWATER OF A GLACIER
6. A POND CREATED BY GLACIERS
7. A RIDGE OF GLACIAL TILL DEPOSITED BY THE ICE

ANSWER KEY

Across:

8. TERMINALMORAINE
9. TILLPLAIN
10. KAME
11. ICEBERGS

Down:

1. GLACIALERATIC
2. OUTWASHPLAIN
3. RECESSIONAL
4. INTERLOBATE
5. ESKER
6. KETTLE
7. MORAINE

CONTINENTAL GLACIATION

K H R E C E S S I O N A L D I J C M L O T
V X M C B A S D R U M L I N M T D U O Q G
Y N A N W L C O N T I N E N T A L M Q P P
A S T D Z U M Q U W Z Q D E B H W F V C J
K E T Q P Z L I T A X Z U U Z Z O J N Q I
N H C F M A X Q M S F I P G W S A C U H C
Q P X D G Y Q N A H D H P Z H N N Z U E B
R I A J Z S J C R P V H O I K M D W I T W
G A D R N E C C G L A C I A L E R A T I C
D V R R R H X T I A L M U B Y O J R S Y U
T I L L P L A I N I L E W C S V R Y K K C
E C X X R V Q T A N E V A O U L Z I F R K
R E T X W Y J Z L X Y G U T C R U U U F O
M B Q M W A Q W L N T C K G U D D Q Z B B
I E K L O M K V A U R M E S K E R O M W P
N R K W U C W M K W A L T K J I N C K P Y
A G H U Z N Y X E T I N T E R L O B A T E
L S Q Q L X T U S G N W L A Z G F S M Q D
O B H D M J H M A S V A E X H V H G E B Q

Can you find these words?

GLACIALERATIC
VALLEYTRAIN
CONTINENTAL
TERMINAL
ESKER
MARGINALLAKES
INTERLOBATE
TILLPLAIN
DRUMLIN
KAME
OUTWASHPLAIN
RECESSIONAL
ICEBERGS
KETTLE

Answer Key for: CONTINENTAL GLACIATION

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. . R E C E S S I O N A L . . . . . .
. . . . . D R U M L I N . . . . . .
. . . . . C O N T I N E N T A L . . . .
. . . . . W . . . . . .
. . . . . A . . . . . .
. . . . . M S . . . . . .
. . . . . A H . . . . . .
. . . . . R P V . . . . . .
. . . . . G L A C I A L E R A T I C
. . . . . I A L . . . . . .
T I L L P L A I N I L . . . . . .
E C . . . . . A N E . . . . . .
R E . . . . . L . Y . . . . . .
M B . . . . . L . T . K . . . . . .
I E . . . . . A . R . E S K E R . . . .
N R . . . . . K . A . T . . . . K . .
A G . . . . . E . I N T E R L O B A T E
L S . . . . . S . N . L . . . . . M . .
. . . . . E . . . . . E . .
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AN INTRODUCTION TO THE OCEANS

Ever since man first looked out over the oceans, the mystic of the unknown has been one of the most intriguing factors encompassing his imagination. For as far as the eye could see, the endless horizon of saltwater left him wandering about what awesome creatures must inhabit such a hostile environment. As was, and still is, indicative of human behavior, the willingness to quench this insatiable thirst for knowledge has led him to the deepest abyssal confines of the oceans floors answering many questions, yet creating more. Our purpose in this unit is to initiate the student into a very basic understanding of the oceans basins and the functions of the waters it holds. While discussing this, we will explore:

-The Oceans of the World

-Importance of the Oceans

-Principle Movements of the Oceans and Their Causes

-Forces of Erosion and Their Affect Upon Shorelines

-Major Shoreline Classification

-Features of the Oceans Basins

-A Political Look at the Oceans

THE OCEANS OF THE WORLD

Seventy one percent of the entire surface of the earth is covered by the ocean's waters. To the average person, this figure is relatively meaningless other than the fact it relates that there is more water than land. To put it into a more realistic perspective, that 71% translates into approximately 140 million square miles of surface area with a total volume of 326 million cubic miles. With sea level being the same everywhere, it become apparent that all of the oceans waters are directly or indirectly connected. For convenience, the five oceans of the world are the:

Pacific

Atlantic

Indian

Arctic

Southern

What is very hard for us to imagine is how the first explorers must have felt as they embarked upon the various voyages into the unknown realms of the oceans. During this early era of our history, vessels were strictly at the mercy of the prevailing winds and ocean currents to move them from one place to another. The most direct route from point A to point B wasn't neccessarily attainable. Add to this the fact that charting these unknown courses sometimes led to disaster due to storms, not taking enough provisions to last the length of the voyage or confrontations with hostile island natives.

Being the largest and deepest of all of the oceans, the mere size of the Pacific was mind boggling in the beginning. As Vasco de Balboa crossed the isthmus of Panama and "discovered" this huge body of water, little did he know how hostile the tranquil appearing ocean could be.

The Atlantic is the "S" shaped body of water which is bordered by the continents

of North America, South America, Europe and Africa. While each ocean has unique traits distinguishing it from the others, the Atlantic displays two in particular. Extend- from an area in between the Spitzenburg Islands and Greenland and running south around the southern tip of Africa, a sub-marine mountain system known as the Mid- Atlantic Ridge dominates this portion of the ocean basin. Several islands including the Azores and Iceland are the tops of some of these mountains.

In addition, and perhaps the most amazing, is the fact that the Atlantic is getting wider each year. Due to a process known as sea floor spreading, the Mid-Atlantic Ridge is literally coming apart at the seems. As the earth opens, magma from deep inside wells up creating new land (mountains). A more detailed explanation of this natural occurence is covered in the unit pertaining to Landforms.

The Indian Ocean is situated in an area which is bordered by Africa to the west, Asia to the north and Australia to the east. The Mid- Atlantic Ridge, a mere section of the much larger Mid- Oceanic Range, extends into and crosses the basin of the Indian Ocean where it also become a dominant feature.

The last two oceans, very similar in characteristics, yet located many thousands of miles apart, are the Polar seas known as the Arctic and Southern Oceans. While the Arctic Ocean is surrounded by the continents of North America, Europe and Asia, the Southern, itself, circumnavigates Antarctica. Here, the frigid temperatures of the polar climates keep most of these waters in a perpetual state of ice. As is apparent, these two oceans do need to be treated separately.

IMPORTANCE OF THE OCEANS

Trying to fully explain the overall significance of our planets oceans in this brief unit would be entirely too big of a task to accomplish. Consequently, our purpose here is to cover but a few major traits which directly influence us almost on a daily basis.

Once again, refering to one of the properties of water which distinguishes it from other liquids, the oceans are able to retain a tremendous amount of heat issued by the sun. Due to the transparent nature of water, these temperatures are both attained and released so slowly that there is actually a seasonal temperature lag which develops. The warmest or coolest temperatures on the average are generally charted towards the end of the high or low sun periods of the year respectively. This, of course, has a very profound effect upon the climates of those lands bordering the oceans. Temperatures here are generally more moderate, not reaching the extremes they do farther inland.

Along the same climatic frame of reference, the oceans are directly responsible for supplying the largest quantities of moisture to our atmosphere on the earth. Through the process of evaporation, approximately 80,000 cubis miles of freshwater, either in the form of a gas, or condensing into tiny droplets of water, are carried by the winds around the globe by the atmosphere's general circulation. Depending upon one's latitude, the directional flow of the prevailing winds and the temperature of the ocean current flowing offshore, lands adjacent to the oceans can recieve tremendous amounts of precipitation, or none at all. (Refer to the unit on Climatic Influences for a more detailed explanation of this happening)

From an ecological viewpoint, the next two factors involve the importance of sea life and it's impact upon mankind. As the tropical rainforests are to the varieties of plants and animals found in those regions, so are the complexities of marine life to the oceans. Throughout the evolutionary process, the development

of these fragile ecosystems have created one of the most intricate as well as interesting food chains found anywhere. Most ocean life is found on the shallower sections of the continental shelf where sunlight penetrates stimulating plant growth through the process of photosynthesis.

From here, the oceans food chains are really not so very much different with but one major exception, man has not encroached upon these areas to the extent he has upon those which are land based. This is not to say our presence has not been felt because the significance of the oceans as a source of food for our growing population is obviously increasing. With the demand for more space needed to support the advancement of human developments, less land is thus being given over for the raising of one of our major sources of protein, cattle. As a result, we are beginning to turn to the sea for this source. Fish not only provide this much needed protein, they are also found in great abundance, another important factor. With this in mind, the more we know about the preservation and maintenance of the earth's hydrosphere, the more secure our future generations are going to be.

Historically, the oceans have provided linkages enabling cultures to sustain and spread their civilizations throughout the world. This, of course, is done through the process of transportation. As cultures began to diversify their economies, additional markets were sought to sell their goods and services. While both the methods and technology of transportation have improved, the basic premise of the oceans being a highway linking together countries and their ideas still holds true.

THE PRINCIPLE MOVEMENTS OF THE OCEANS AND THEIR CAUSES

Have you ever been on a vacation to an ocean front beach? As you look out over the vast area of the sea, you probably have noticed there is a great deal of movement going on within those waters. Actually, the combined mass of the oceans undergoes three separate, but decisive movements, all occuring at the same time. In examining each of these movements, keep in mind occurences in nature have definite sources.

Waves, the most obvious or visual movement, affect merely the surface layers of the seas. This rythmic "up-down" motion provides an atmosphere which is synonymous with ones mental images of the sea. The sounds of waves crashing upon the shore can easily be detected as you approach the area. Waves are caused by the drag of the prevailing winds. Simply put, as winds flow across the flat surface of the seas, they "pull" the water creating this movement.

Tides differ from waves in that they are more regular and affect the entire mass of the oceans waters. Then one stops to consider how much weight must be involved, the force required to move such a mass must be phenomenal.

Tides are actually induced by two factors, the gravitational attraction of the sun and the moon and the centrifugal force of the earth's rotation. The oceans on that side of the earth facing the moon are "pulled" into high tide by the moon's gravitational force. Depending upon the contour of the coastline, the affect on the land involved differs.

High tide also exists at the same time on the direct opposite side of the earth not facing the moon. Water here is "thrown" into high tide by the earth's rotational speed. This is the phenomenom known as centrifugal force. The two high tides are approximately 12 hours apart.

Low tides occur on those sides which are neither affected by the moon's gravity nor the earth's rotational speed. Located on the adjacent sides, these also occur

approximately 12 hours apart. (It should also be noted that the depth of the oceans and the configuration of both the coastline and oceans basin also affect the tides.)

Due to the earth's rotation, all freely moving objects are deflected to the right or left downstream from the point of origin, depending on the hemisphere (north or south). This coriolus force, in conjunction with the differences in density of the sea water, set up the earth's ocean currents.

Currents can be catagorized according to temperature and strength. In general, those currents which originate within the tropical regions and flow poleward are classified as warm. Those which originate in the polar areas and flow towards the tropics are termed cold. Two noticeable exceptions to this are the California and Cannaries currents. Both being cold and located in the middle latitudes, these currents are actually the result of deep channel currents from the ocean floor rising towards the surface following the natural configuration of the continental slopes and shelves of North America and Africa respectively.

Strength, or flow, is also a significant factor in need of mentioning. As you look at a thematic map depicting the earth's ocean currents, you will notice the terms stream, current and drift. These are ranked in accordance to shere force with the stream being the strongest and the drift the weakest.

OCEAN CURRENTS

PACIFIC OCEAN

1.	ALASKAN(ALEUTIAN)	WARM
2.	JAPAN(NORTH PACIFIC DRIFT)	WARM
3.	CALIFORNIA	COLD
4.	NORTH EQUATORIAL	WARM
5.	EQUATORIAL COUNTER	WARM
6.	SOUTH EQUATORIAL	WARM
7.	HIMBOLDT(PERU)	COLD
8.	KAMCHATKA	COLD
9.	OYASHIO(OYA SIWA)	COLD
10.	KUROSHIO(KURO SIWA)	WARM
11.	EAST AUSTRALIAN	WARM

ATLANTIC OCEAN

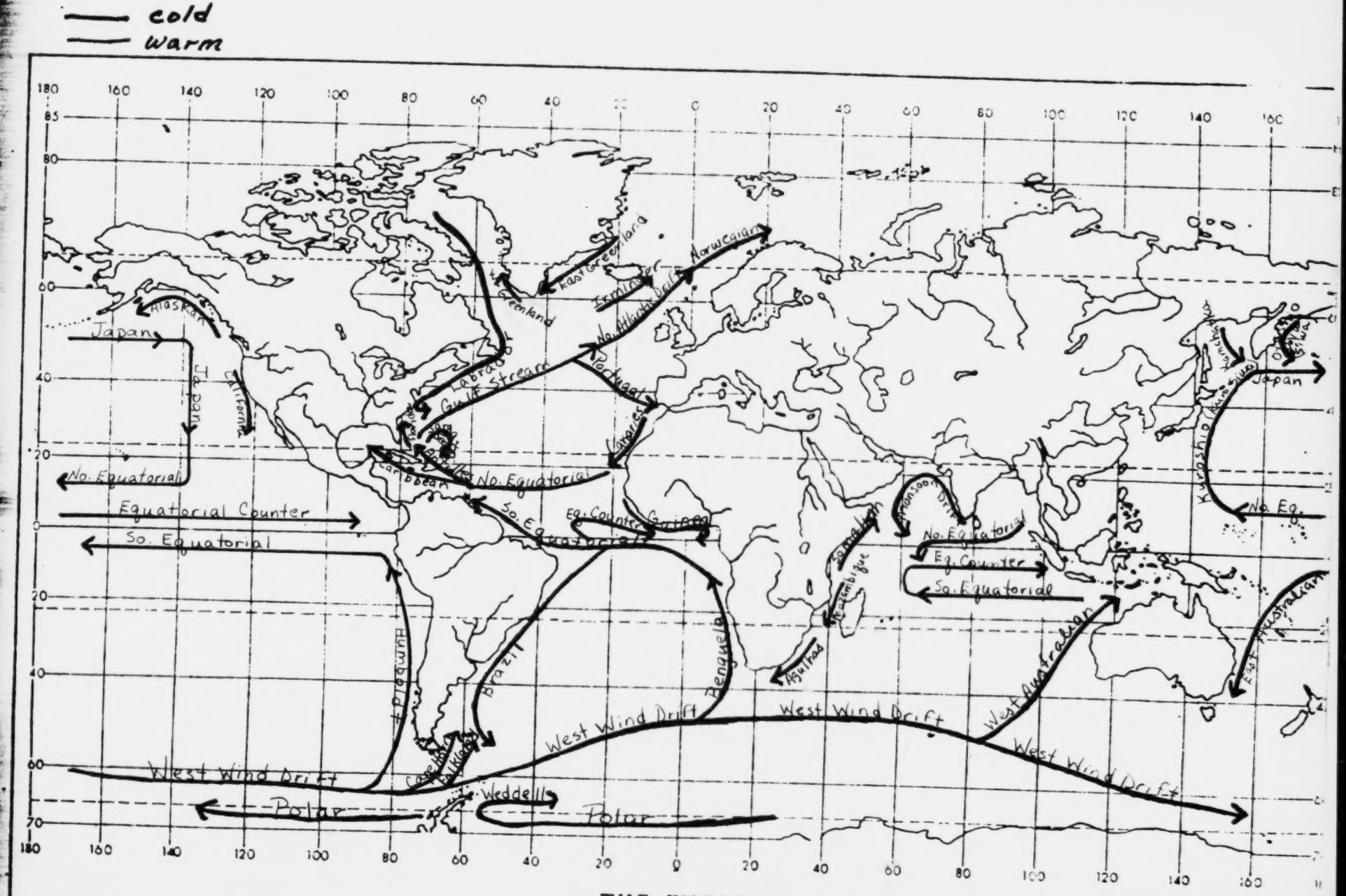
1.	LABRADOR	COLD
2.	EAST GREENLAND	COLD
3.	WEST GREENLAND	WARM
4.	FLORIDA	WARM
5.	GULF STREAM	WARM
6.	NORTH ATLANTIC DRIFT	WARM
7.	IRMINGER	WARM
8.	NORWEGIAN	WARM
9.	PORTUGAL	WARM
10.	CANARIES	COLD
11.	NORTH EQUATORIAL	WARM
12.	SARGASSO SEA	WARM
13.	EQUATORIAL COUNTER	WARM
14.	ANTILLES	WARM
15.	CARIBBEAN	WARM
16.	SOUTH EQUATORIAL	WARM
17.	GUINEA	WARM
18.	BENGUELA	COLD
19.	BRAZIL	WARM
20.	FALKLAND	COLD
21.	CAPE HORN	COLD

INDIAN OCEAN

1.	MONSOON DRIFT (NORTHEAST MONSOON)	WARM
2.	NORTH EQUATORIAL	WARM
3.	EQUATORIAL COUNTER	WARM
4.	SOUTH EQUATORIAL	WARM
5.	SOMOLIAN	WARM
6.	MOZAMBIQUE	WARM
7.	AGULHAS	WARM
8.	WEST AUSTRALIAN	COLD

SOUTHERN OCEAN

1.	WEST WIND DRIFT	COLD
2.	POLAR	COLD
3.	WEDELL	COLD


cold
warm
Japan
Alaskan
California
Japan
No. Equatorial
Equatorial Counter
So. Equatorial
Labrador
Gulf Stream
Greenland
East Greenland
Irminger
Norwegian
No. Atlantic Drift
Portugal
Canaries
Caribbean
No. Equatorial
So. Equatorial
Eq. Counter
Guinea
Brazil
Benguela
Humboldt
West Wind Drift
West Wind Drift
West Wind Drift
Polar
Weddell
Polar
Somali
Mozambique
Agulhas
No. Equatorial
Eq. Counter
So. Equatorial
West Australian
East Australian
Kuroshio
Japan
No. Eq.
THE WORLD
Richard D. Wright
Cartography Laboratory, Dept. of Geography, Iowa Univ.

THE FORCES OF EROSION AND THEIR EFFECT ON SHORELINES

Obviously, as these movements take place, the forces of erosion and weathering directly influence the shape and appearance of the earth's coastlines. Erosion happens to be the wearing away of the earth's surface features through the agents of wind, water and ice. Upon examining each agent individually, it becomes evident how collectively they are the major factor influencing the earths shores.

Wind uses a technique known as abraision as it cuts into landforms. Tiny particles of abraisives (sand or dirt) are transported by the wind striking objects they come in contact with. The extent of the cutting depends upon the winds velocity and duration. Consequently, over a period of years, wind becomes a force landforms eventually fall prey too.

The erosive property of water, as discussed in the unit pertaining to Freshwater Resources, depicts the fact that in due time water will dissolve almost anything of natural origin. Here we have the stages of sheet, rill, gulley and badlands actively at work.

Ice, as an erosive agent, influences coastal areas in two different fashions. Glaciers, like huge bulldozers with their blades down, cut and scrape all lands they move across. Those regions which are literally riddled with fiords best exemplify this.

In a very different manner, however, the melting or formation of the polar ice sheets is directly responsible for the fluxuation of sea level. Since the termination of the last ice age, sea level has been rising on an average of 1 inch every 100 years. As the level changes, so does the appearance of the coastlines.

The entire concept of weathering, as a destructive agent, is much different than that of erosion. With weathering, there is no physical movement involved at all. The actual process must be observed over an extended period of time. In a very

subtle way, the agents of air, gravity, frost action, salt crystallization and tree roots also have much to do with the shores appearance.

Specific shoreline erosion is the result of wind blown water and shore currents which wear away the rock and soil of the coasts they come in contact with. When waves reach the shallow waters adjacent to the shores, they break and flow as a current either along the shore or along the bottom towards deeper waters as an undertoe.

This persistant pounding of the waves upon a shore sometimes creates very distinctive erosional features. That one must realize is that not all shorelines contain beaches. With this in mind, let's consider the formation of sea arches, sea stacks and sea caves.

Waves which attack promontary points (high points of land extending into the sea) cut away the headland thus producing cliffs. Subsequent erosion undermines portions of the headlands leaving the coastal formations known as sea arches.

When only the most resistant portions of the original headlands are left standing totally disattatched, offshore, features known as sea stacks are created.

Lastly, as waves continue to pound the cliffs of an existing shoreline, sea caves can be created as porous sub-rock is eroded.

MAJOR SHORELINE CLASSIFICATIONS

Although the agents of erosion and weathering are instrumental in shaping the the earth's coastlines, other forces are actually responsible for their development. Notice I am using the plural form when refering to coastlines, because in reality there are actually five.

'A Shoreline of Submergence'

A shoreline of submergence is the result of one of two factors. First of all, the earth's crust near the border of a land area could sink as tectonic activity is at work. As this happens, the sea covers that land which at one time was exposed to the earth's atmosphere.

If the crustal regions of the earth are not affected, submerged shorelines can still form if the sea level around the earth rises. As noted earlier, sea level is affected when the continental ice sheets of the polar regions begin to melt. If, in deed, sea level is rising on the average of 1 inch every 100 years, it obviously requires a phenomenal amount of stored up water to fill the 140,000,000 square miles of surface area the oceans cover to that level. Where else except the polar ice caps would such quantities exist?

Three distinct examples of submerged shorelines can be sited around the world. Where a region has been dissected by streams into a system of valleys and divides, submergence produces highly irregular embayment shorelines. Former valleys become deep embayments. Former hilltops become islands. Former divides between valleys become promontories or peninsulas. What is being described here is a ria shoreline.

As mountain or valley glaciers cut their way towards the sea, the trough they cut is generally excavated below sea level. Extending inland a considerable distance, as the glaciers receed and sea level rises, water from the oceans inundate these valleys creating very deep-steep walled areas known as fiords. As harbors, fiords provide

excellant protection from raging storms occuring out in the open seas.

The final example of a submerged shoreline is located in what was once a delta. As the sea level once again rises, ocean water travels inland up the delta and into the river channel itself. Being the river cuts a "V" shaped valley, the mouth now becomes very wide and deep, deep enough to allow ocean going vessels the ability of traveling inland a considerable distance. This particular type of submerged shoreline is known as an estuary.

'A Shoreline of Emergence'

In the exact opposite manner, the shoreline of emergence is also formed as the result of two possible occurrences. Whereas the submerged shorelines originated from either a sinking of the earth's crust near the border of a continent or a rise in the sea level, emerged shorelines develop as the result of a rising of the earth's crust near the border of a land area, or the lowering of sea level. Land which was once covered by the oceans waters is now exposed to the earth's atmosphere. This produces a low, smooth, gently sloping coastal plain bounded by a simple even shoreline. Along some of these coastline belts, the submarine topography may contain very steep slopes with deep water lying close offshore and mountains farther inland. Once again the crustal movement is caused by tectonic activity and the fluxuation of sea level by the formation of new continental ice sheets.

'A Neutral Shoreline'

Under certain circumstances, when there is neither crustal movement nor a change in the level of the sea, new materials are added to the existing shoreline extending it further out into the sea. These neutral shorelines on the surface may not seem too plentiful, however, in reality there are four distinct types.

As described in the unit pertaining to Freshwater Resources, deltas are large deposits of silt and sediment located at the mouths of rivers as they empty into a much larger body of water such as a sea or ocean. These depositional features are

are literally the dumping grounds for extensive river systems as water from the continents flows into various drainage basins and makes it's way towards the sea. A particular case in point is the Mississippi River delta located basically south of the city of New Orleans, Louisiana. The Mississippi River is fed by the major tributaries of the Missouri, Ohio and Arkansas rivers. It has a total length of 2330 miles and a total navigable length of all the rivers in it's system of about 16,090 miles. As you can see, the constant flow of these rivers bring vast quantities of debris downstream which eventually end up in the delta. The site where the present day city of New Orleans is located use to be on the shores of the Gulf of Mexico. Today it is located 50 miles inland.

Alluvial fans are formed very much like deltas except on a much smaller scale. Generally curved in outline at it's end, these depositional features develop at the mouths of small coastal mountain streams as they empty into larger bodies of water.

The reason for the size difference is really two-fold. First of all, the mountain stream which flows over a much harder surface does not carry as much debris with it on it's journey downslope. Consequently, less will be deposited at the base. The other reason has to do with the length and extent of tributary contribution. A coastal mountain stream flows a much shorter distance to the sea and has far fewer tributaries of any size flowing into it. Alluvial fans are also built by braided streams.

Volcanic shorelines really don't require much imagination in understanding how they develop. Occuring where volcanic eruptions have taken place, the slope of the volcano or the edge of the flow may compose the shore. When the lava flows directly into the ocean, it cools dramatically continuing to pile up ever so slowly as long as the flow from the volcano continues. What is happening is that the shoreline is being extended further out into the sea. The Hawaiian Islands are excellant examples of these types of shores.

If you have been reading carefully, you will have noticed the first three neutral shorelines were built from deposits originating on the land. The last is quite different not only in that it originates in the oceans, but also in that it is actually built by tiny marine animals known as polyps. Polyps thrive in the shallow tropical waters of the earth. Having no internal skeleton, nature has provided this creature with the ability of extracting calcium carbonate from sea water thus constructing an external skeleton called coral around it for protection. After the coral has established a foot hold in an area, polyps become sedentary remaining in one spot. As older polyps die, newer ones build upon the older remains developing colonies. Once the colonies begin to spread, you get the formation of the final neutral shoreline called the coral reef.

Coral is very strong and resistant due to it's limestone core consisting of the cemented limy skeletons of dead polyps. As with all life forms, a certain type of environment is neccessary for the widespread development of coral reefs. Coral basically occurs in the warm tropical waters of the earth between 30 degrees north latitude and 25 degrees south latitude where the water temperatures remain at a minimum of 70 degrees F. The waters must be free of suspended sediments which indicates coral will not develop around deltas or alluvial fans.

Being that polyps are stationary creatures, swift currents must also be present so a fresh supply of food can be brought to them regularly. Polyps eat what is known as plankton (microscopic plant and animal life of the sea).

Reef coral lives near the surface of the sea down to a maximum depth of 250 feet. At this point, sunlight begins to filter out diminishing the temperatures to below that of 70 degrees F.

Coral reefs are generally found in 3 different varieties. The fringing reef is a coral reef which is attached directly to the mainland. They are widest in front of headlands where wave attacks are the strongest. Here they receive clean

water and an abundance of food. Fringing reefs may be anywhere from 0.5 to 1.5 miles in width.

The barrier reef is a coral reef which is separated from the mainland by a shallow body of water known as a lagoon. Ranging from 0.5 to 10 miles in width, the lagoon is a shallow body of water with a flat floor usually 120-250 feet deep. Towerlike columns of coral usually develop here.

Passes, or narrow gaps, through which excess water from breaking waves is returned to the open sea, occur at intervals along the barrier reef. The normal reef itself ranges in width from 20 feet to 3000 feet. The one exception is the Great Barrier Reef which lies off of the northeast coast of Australia next to the province of Queensland. This massive formation is over 1000 miles in length and has taken millions of years to develop.

The final reef, known as a coral atoll, is a circular coral reef enclosing a lagoon but without any land inside. While coral atolls are similar to barrier reefs, in certain instances, larger atolls can actually form the base of islands. This is accomplished as parts of the reef are built up by wave action and winds. These lower elevated island chains are usually connected by reefs.

'The Faulted Shoreline'

The fourth major coastline is called a faulted shoreline. This particular type of coast is produced when faulting occurs within the earth's crust in such a way that there is a dropping of a segment of the crust on the seaward side of the break and a corresponding uplift on the leeward side. Should the downdropped block subside below sea level, the shoreline will come to rest against the steeply sloping land surface which is the surface of the plane or fault.

'The Compound Shoreline'

The compound shoreline is the last example of the earth's shores. Perhaps the easiest to describe but one of the more complex examples, the compound shore is a combination of 2 or more of the previously described classes of major shorelines.

FEATURES OF THE OCEANS BASINS

Prior to the 1920's, almost all knowledge pertaining to the oceans basins was shere speculation. Using what tools made available to them at the time, the scientific community often drew conclusions based mainly on logic and reason. Being man could not see very far beneath the seas, scientists surmised that the bottom must be very flat due to all of the sediment which had been eroded off the continents and deposited over the billions of years of the earth's existance. Surely any feature which was down there had been covered up.

During the period of our history when World War I was raging, scientists developed a devise which was initially intended to detect the dreaded German U-boats. SONAR, as it became known, is an accronym which stands for Sound, Navigation and Ranging. The basic premise behind SONAR is that sound travels 1100 feet per second at 0 degrees centigrade. For every 1 degree change in temperature, the velocity of sound either increases or decreases 2 feet per second. By bouncing sound waves off of an object through the SONAR deviseand then calculating the ellapsed time it takes to return, a distance between the two objects can be determined. Vertical distance in the oceans is translated into depth so SONAR was soon used to determine the depths of the oceans basins. As science advanced, so did the technique of using SONAR. Today, an instrument known as an Echo Sounder is used to map the floors of the oceans. What we now know about the oceans basins paints a very different picture from the flat bottomed concept of the earlier scientists.

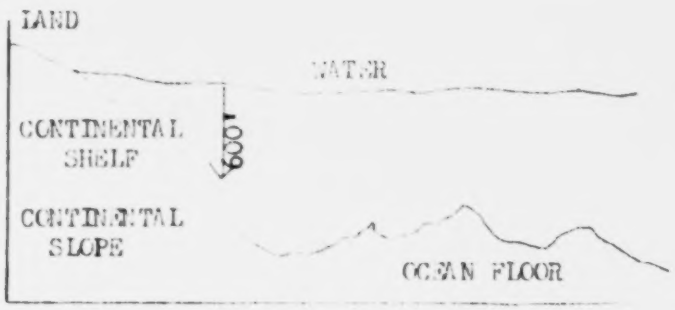
Thanks to these early efforts, we now know that there exists a wide variety of topographical features beneath the oceans surface. In our attempts to better understand these features, we have catagorized them into 3 basic areas according to their common traits.

The Continental Margin is the zone of separation between the continent or land area and the ocean floor. This unique region is divided into 2 major divisions

actually according to depth. The Continental Shelf, an extension of the existing continent, extends outward horizontally until a vertical depth of 600 feet is reached. At this point, the shelf ends and the Continental Slope begins. As the name implies, the slope is an abrupts drop-off leading all the way down to the ocean floor. It should be noted at this point that the most prolific existance of life found anywhere exists on the Continental Margin.

The Ocean Floor, the second major division of the oceans basins, is a very diverse region which has more physical features located on it than all of the continents combined. Two exceptional ones, the guyot (pronounced geo with a hard g) and the trench are found here. Guyots, sub-marine volcanoes and trenches, very deep depressions which are boundaries between two colliding tectonic plates, differentiate the floor from other topographical areas.

While the Ocean Floor comprises about $\frac{1}{2}$ of the total area of the earth, it should not reallt be labeled a "floor." Being anything but flat, most ocean beds are rubbed and corrigated each having their own trenches and characteristics.



The final segment of the oceans basins is the Mid-Oceanic Ridge. This submarine mountain range weaves a total distance of approximately 40,000 miles across the Atlantic, the Indian and the Pacific Oceans. It's mere size makes it a separate feature in and of itself.

A more comprehensive look at the relief features of the oceans basins is examined in the unit pertaining to Landforms.

A POLITICAL LOOK AT THE OCEANS

Concepts in relation to ownership have been points of open discussion and even warfare throughout history. Today is really no different. As we look at the world in which we live, nations are actually staking claims or using their influence upon others to do so. Why, then, should it be any different amongst those nations bordering a sea or ocean? In many respects, they have more at stake than those land locked nations located further inland. From their point of view, they have 5 areas or zones of concern to openly contend with on a daily basis.

The air space above the territorial seas must be maintained and patrolled regularly to prevent espionage and possible aggressive behavior taken by hostile nations.

The water surface, located directly off the coast, must also be patrolled to prevent the illegal entry of contraband into the nation,

Subsurface waters, in relation to fishing rights, is an important economic issue which must be addressed and then enforced if people depending upon their territorial seas for a livelyhood are going to survive.

The last two, the bed of the sea and subsurface rock both pertain to mineral exploration. If vast quantities of oil are found off the coast of a developing nation, who else but the people of that nation should benefit from that important discovery?

It was during the mid 1950's that the United Nations held a very historic conference in the city of Geneva, Switzerland which set up guidelines to offer coastal nations a sense of security and control in relation to the waters directly off their coasts. Known as the Geneva Conference, the standards set by that conference were refered to as Article #24- The Law of the Sea. These zones of diffussion were catagorized according to distance from the shore and purpose.

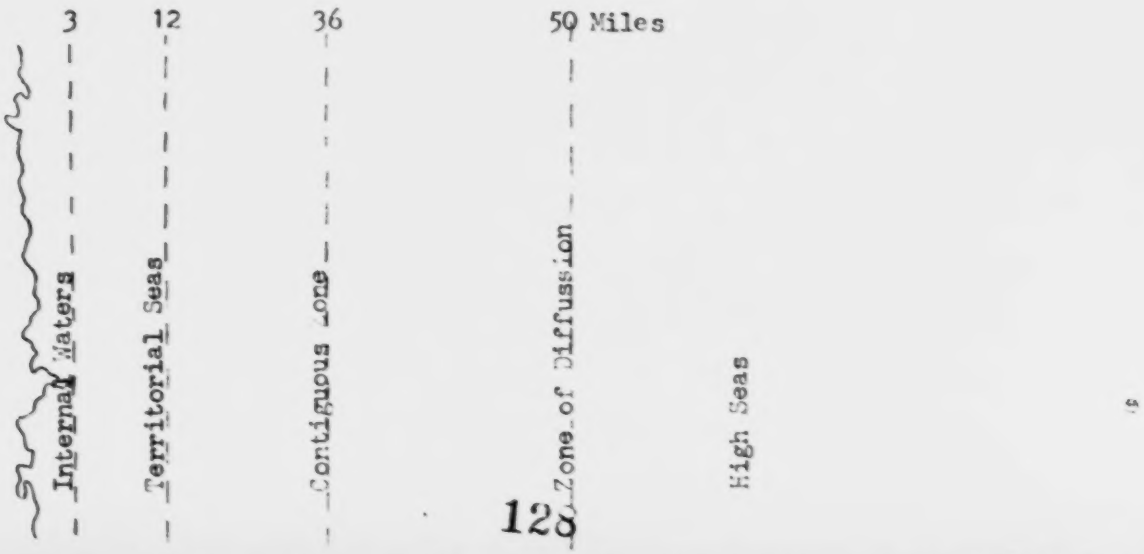
The internal waters were designed to extend outward from the coastline a total distance of 3 miles. Actually being an extension of the continent, the same laws which applied to those coastal nations involved would also apply here as well.

Extending outward a total distance of 12 miles from the shore was the territorial seas. Here, fishing limitations were established. No nation would be allowed to fish within this area without the consent of the governing nation. Nations disregarding these regulations were subject to disciplinary measures determined by the nation itself.

States bordering a sea also have the right to inspect any vessel suspected of harboring illegal immigrants, carrying disease or violating customs laws. This region known as the contiguous zone, actually extends outward from the shore a total distance of 36 miles.

The zone of diffussion is an area in which the Coast Guard or other law enforcement officials have the right to patrol in order to inhibit smuggling or other illegal acts, but actually have no legal sanctions in the enforcing of the laws. Extending a total distance of 50 miles from the shore, the main purpose of this region is to closely scrutinize any ship held in suspect in hopes of detering their efforts.

Lastly is the area known as the high seas. Beyond the 50 mile mark, the seas are open to any ship.



Today, some 30 years after the signing of Article # 24, many nations, including the United States, have pushed those boundaries farther out into the sea actively controlling a boundary of up to 200 miles from the shore. Historically, the 200 mile limit came into focus when the Pacific coastal countries of South America engaged in confiscating any vessel and it's crew coming within 200 miles of their shores while fishing primarily for tuna. Refered to as the "Tuna Wars," much contraversy was stirred up on a world wide basis due to the fact that the fishermen involved were held for ransom.

Things are not quite that bad today. The same laws which were applied to the Law of the Sea are also enforced in the new territorial limits. In the final analysis, the question pertaining to the ownership of the seas is always going to be debated, but much of the decissions are going to be based on time and reason.

Questions for Assistance

The Oceans of the World- Principle Movements of the Oceans and their Caused

1. In reference to volume, approximately how much water is held in the world's oceans basins? How much surface area does this incorporate?

2. List the 5 oceans of the world.

3. List the 5 significant factors the oceans provide which are of absolute significance to the sustinance of life on our planet.

4. List and define the three principle movements of the oceans.

5. How does the rotation of the Earth influence tides on the opposite side of the Earth not facing the moon?

6. What force of the Earth's rotation influences the directional flow of ocean currents and how?

7. List the 5 principle causes of the movements of the oceans.

8. Describe the temperature of each of the following ocean currents (warm or cold):
   a. Benguela
   b. Mozambique
   c. Humboldt
   d. Labrador
   e. Gulf Stream

9. List three branches of the West Wind Drift.

10. Which warm ocean current, located off the southern coast of Alask, is responsible for the moderate climate southern Alaska experiences during the course of a year?

11. Which oceans currents flow "directly" off of the west coast of Africa?

12. Which ocean currents are directly and indirectly responsible for the ice free ports located off the west coast of Norway?

13. Which ocean current flows directly off the west coast of the United States?

14. In which ocean are the following ocean currents located:
   a. Agulhas?
   b. Sargasso Sea?
   c. East Australian?
   d. Weddell?
   e. Humboldt?

15. Which ocean current flows directly in between the East Greenland Current and the North Atlantic Drift?

16. Which two ocean currents are located at the very southern tip of the South American continent?

17. Is the West Greenland Current warm or cold?

Questions for Assistance

The Forces of Erosion and their Effect upon Shorelines-Major Shoreline Classifications

1. _____ is the wearing away of the Earth's surface.
2. List the three agents of erosion.
3. _____ is the cutting work of wind.
4. List the four stages of water erosion.
5. How does the concept of wearthering differ from that of erosion?
6. Distinguish between sea stacks, sea arches, and sea caves.
7. List the five major classifications of shorelines.
8. List the two possible causes for:
   a. a submerged shoreline.
   b. an emerged shoreline.
9. List and define 3 examples of a submerged shoreline.
10. How do neutral shorelines differ from those which are submerged and emerged?
11. List and define four examples of a neutral shoreline.
12. In reference to coral reefs, what minute marine animal is responsible for the development of coral and how?
13. List four criteria neccessary for the development of coral.
14. List and define three varieties of coral reefs.
15. Distinguish between a faulted and compound shoreline.

Questions for Assistance

Features of the Oceans-A Political Look at the Oceans

1. How did the development of SONAR lead to the eventual mapping of the oceans basins?

2. Which by product of the development of SONAR is now being used in the mapping of the oceans basins?

3. List the three major divisions of the oceans basins.

4. List five zones of concern nations bordering the seas have to contend with on a daily basis.

5. List and describe the five zones of diffussion as set down by the Geneva Conference, Article # 24, The Law of the Sea.

6. How have many nations changed these initial concepts of the zones of diffussion over the past several years and why?

AN INTRODUCTION TO WORLD VEGETATION

Plants are structurally or architecturally designed to survive in the environment in which they exist. That, in and of itself, is a rather profound but nevertheless factual statement. If the adjustments to these environments are not made, plants simply cannot exist. Let's see why this is true.

Vegetation can be defined as the total array of plant life, or as Webster's New World Dictionary puts it, "plant life in general". What is difficult for some of us to remember however, is that plants do not confine themselves totally to those areas of the earth away from the realm of water. Vegetation is found in both the oceans (saltwater) and the fresh surface waters such as lakes and ponds as well. Irrespective of those areas, we are going to limit our studies to those land based plants and the ecosystems in which they are found. While exploring the plant kingdom, we will be examining:

Environments: Systems of Adaptation

Vegetative Regions of the World

ENVIRONMENTS: SYSTEMS OF ADAPTATION

The environments of any given region are those features which surround us, influence us and cause us to adapt to whatever conditions exist in that region. As we stop to consider all of these factors, it should become quite obvious that our surroundings are somewhat complicated and should be broken down into whatever component parts are neccessary to better understand them. As a result, 3 very distinguishable elements exist within any environment. It should be noted, however, that while they are separable, they still function as one when the total picture is observed.

The first involves the physical features of an area. One's physical environment includes those features within a given region which are inorganic, non-living or never having lived. The catagories of air, water, landforms and climates are all displayed here and play a very intricate part in the types of life forms existing within the area. Imagine the differences which must exist between the physical environments of Lhasa, Tibet which is located on the Tibetan Plateau of China with an elevation of 11,830' and Shanghai, China which is located on the coast of the East China Sea at sea level. As you can see, the physical differences which exist within each region in essence affects both the plant and animal life.

The second involves the biological surroundings within a given sector. This biological environment consists of those features which are organic, living or having once lived. Plants and animals make up this realm and directly inter-relate with their physical surroundings.

When one considers the earth as a whole, the biological environment is termed the biosphere. This section of the earth consists of those areas where life exists. At one time in our past, scientist thought they could identify a few areas where no life of any kind existed. Our scientific knowledge of life was based upon or confined to those forms which totally owed their being to the forces of the sun.

As the sun stimulated plant life through the process of photosynthesis, other plants and animals which fed upon those plants began the makings of a food chain. The carnivorous and omnivorous animals added to the ladder and eventually we had the links of the food chain complete with the beginnings traced back to the sun. Not until recently have we found life forms located in the abyssal regions of the ocean floor which derive their nutrients and existance from minerals extruded from volcanic vents.

In another instance, the "dry valleys" of Antarctica have recently been analyzed and a type of lichen formation which was actually growing within the rocks themselves was discovered. With the extremely harsh conditions of the Antarctic environment, this was the only foothold these plants could grasp.

Realizing this, perhaps our understanding of the biosphere will broaden as additional research and the accumulation of data continues.

With a closer examination of the biosphere, the fact is revealed that this vast region can be sub-divided into 3 smaller groups, each exhibiting their own traits or characteristics. Known as <u>biocycles</u>, these distinct regions consist of life forms found on land, in freshwater, and in the oceans (saltwater). The obvious difference each biocycle presents makes it clear that a different set of standards must be met before life forms can exist with any regularity.

By further examining the biocycles, we can sub-divide them into specific catagories pertaining to the plant kingdom. Called <u>biomes</u> or <u>biochores</u>, the communities of forests, grasslands, deserts, and tundras all become very distinct and easily recognizable. As we survey the vegetative regions of the world, we will examine each biome somewhat thoroughly.

Lastly, those aspects of our environment which are man made and are designed to stimulate that thought which is to be passed down from generation to generation is called the <u>cultural environment</u>. As is evident, our physical and biological

surroundings greatly influence how we live, what we eat, and to a great extent the type of economic endeavors our society engages in. With the knowledge we have accumulated over our centuries of existance, however, we tend to alter our environments to suit our specific desires. In other words, all three aspects of our environment are inter-related.

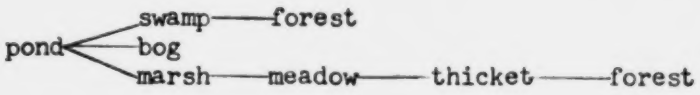
"Adaptation"

The role that plants and animals take in adjusting to their surroundings is called <u>adaptation</u>. As stated earlier, plants are structurally designed to grow in specific areas. Any change in that environment must be compensated within the plant if it is to survive. A case in point is the very prolific existance of the needleleaf tree. Ranging from the very frigid confines of northern Canada and Siberia all the way to the near sub-tropical regions of the south, these trees have evolved as a result of several strustural changes or adjustments. The leaves of the needleleaf tree are shaped as such limiting the amount of surface area thus restricting or limiting the amount of evaporation which could take place. The sap, being very thick, has a two-fold purpose. Firstly, it too restricts the amount of moisture which could be evaporated out of the trunk of the tree. However, equally as important is it's insulation quality which protects the tree during the extremes in temperature.

By picturing the cones of the needleleaf tree, you can see that each one is divided into segments. These cones carry pollen which in neccessary in the reproductive cycle of the tree. Considering the number of cones each tree has the capability of producing in it's life time, you can appreciate how nature has equipped this tree with the ability to survive.

As environments gradually change over a period of years, plants too must adapt to these changing conditions, however, during times of stability, certain lesser changes also occur. This very orderly change or transferal of one plant community to another is called <u>natural succession</u>. During this phase, plant communities of various species replace others as the environments to which they have adapted

are being replaced. The following diagram depicting the natural succession of plant communities in a middle latitudes environment will give you an idea as to how this actually takes place.



As we study this diagram, our beginning point is the pond. A pond is a shallow, enclosed body of freshwater which, due to it's depth, allows sunlight to penetrate and strike its floor. Through the process of photosynthesis, plant growth is thus stimulated throughout all parts of the pond. Each year, two layers of sediment are added to the pond decreasing its depth. Known as varves, the layer added to the pond in the fall and winter consists of decaying vegetative matter which died due to the colder temperatures. The layer of sediment added during the spring consists of dirt which was washed in during the spring rains. Over a period of years, as the depth of the pond becomes shallower, plant life begins to surface which changes the entire structure. The pond is no longer classified as such. Instead, it becomes either a swamp, a bog, or a marsh depending upon the type of vegetation being displayed.

As time progresses, these wetlands undergo changes as they too begin to dry up. The swamp may change directly into a forest. The bog and the marsh change into a meadow with the possiblity of the forward progression stopping at this point, depending upon the climate. If not, shrubs and evergreen trees known as cedars begin to move in. The thicket, as it is now called consists of many closely growing plants which creates an environment condusive to the habitation of many small animals.

Once again, depending upon the climate, the type of forest which evolves next could either be an evergreen, a broadleaf, or a mixed. At any rate, once this final stage of succession is reached and the plant community itself does not change, but instead continues to renew itself, a climax community has been established.

While it is possible for the succession of plant communities to be set back naturally, in most cases man enters the picture and alters these regions through the development of land. What is interesting, however, is the fact that if these areas were left alone and not tampered with at all, they would eventually revert back to the climax community from which they came.

"Building Blocks of Adaptation"

It almost appears as if plants take on a human quality as they tenaciously make the neccessary adjustments needed to survive in an environment. These adjustments must be made in relation to 2 elements found within every enivironment, those being climate and soil. While these 2 are actually separate sciences and can be discussed in great detail, our purpose here is to relate them to the plant kingdom and show what relevance they have.

'Climate'

Climate can be defined as the average weather conditions recorded over a particular area for an extended period of time. In essence, it is the result of a number of different qualities which, in combination, dictate the type of weather conditions regions can expect to experience at various times of the year.

Latitude, as related to climate, makes reference to distance from the equator. In general, the further away from the tropical regions of the world one travels, temperatures decrease. This is one of the main reasons species of plants range from the broadleaf evergreen trees of the tropical rainforests to the grassy tundra plains and lichen covered areas of the Arctic.

Nearness to water has a distinct affect not only on precipitation but also on temperature within a given region. Lands located in the centers of large landmasses, great distances from large bodies of water, have a tendency to receive less rainfall and experience wider ranges of temperatures during the course of a year than those located closer to those same bodies of water.

Moreso than with precipitation, plants find it difficult to adjust to temperature extremes. These extremes are calculated as the difference in temperature from the warmest day of the summer to the coldest day of the winter. The largest extremes mainly occur in the middle latitudes in regions of North America, Europe and Asia.

Ocean currents have a very profound affect upon the temperature and precipitation of an area. As a rule of thumb, lands adjacent to warm ocean currents are warmer and receive more rainfall whereas lands adjacent to cold ocean currents are cooler and somewhat drier than the lands located further inland.

Altitude is basically distance above a given surface. The higher one gets in altitude, the temperatures decrease. This can best be explained by the simple discussion of terrestrial radiation. As the sun heats both the land and water features of the earth, they in turn release that heat directly influencing the temperature of the air above. Thus, warmer temperatures are generally registered closer to the earth's surface. The farther away you get from this secondary heat source, the colder the temperatures get. This has a definite affect in localized areas such as high plateaus and mountainous regions.

In conjunction with altitude, elevation has a similar affect upon climate, but in a much broader sense. As stated, altitude refers to localized areas, whereas, topography can affect a very broad area on the face of the earth. If one considers Africa as a tilted plateau, the plant life found in the regions of the lower elevated west coast is different than that found in the eastern highlands. Once again, temperature is the influencial factor here.

Air masses have a great deal to do with weather conditions and the movement of air from one place to another. As they move, specific weather characteristics from the region over which they develope are brought with them. If an air mass developes over a source region which is cool and dry, the air moving into an area will be cool and dry. At times, however, when geographic conditions are right, air masses displaying opposite characteristics mix creating very severe storms. When this happens, plant and animal life alike suffer the consequences and must learn to adapt.

The last climatic quality which should be mentioned is storms. Known as tropical cyclones, these are mother natures worst display of atmospheric forces. Tremendous amounts of rain and wind speeds in excess of 74 miles per hour batter coast lines and often times damage all life forms present. Obviously plants (which cannot take shelter) must to learn to survive these forces if they are going to continue to grow in such hostile surroundings.

'Soil'

The second building block or foundation upon which plants are molded is the soil. The type of soil and the mineral content therein is to a great extent related to the climatic elements and the vegetative forms growing in the region. As the base minerals of nitrogen, phosphorous and potassium begin to develope in the soil, plant life of a specific nature begins to grow in accordance with these environmental characteristics. In areas weak in the base minerals, plants must improvise in order to survive.

How minerals develope in the soil is directly related to the decomposition process of plant and animal matter. In the very hot and humid climates, this matter decomposes very rapidly. This is not advantageous in the respect that the minerals which should be enriching the soil are usually leached or washed away. This is known as rot and can be compared to how herbs ans spices are supposed to be used in the preparation of certain foods. The secret of unlocking the flavors of herbs and spices is to allow them to escape slowly. By cooking foods over a high heat too rapidly, the intended flavors are literally cooked out. On the other hand, by cooking the intended foods over a low heat for an extended period of time, the flavors of the herbs and spices are allowed to permeate every part of the dish giving it the intended taste. In climates where the temperatures and rainfall are moderate, decomposing vegetative and animal matter break down slowly thus allowing the soil to retain the minerals. This is known as decay.

Upon examining the formation of soil in various climates around the world, 5 processes can be identified and will be briefly described here in order to show the relation which exists between climate, soil and vegetation.

In the very warm and humid regions of the tropics, a process known as laterization is responsible for the development of the soil. Known for it's high content of metallic minerals, the ore of aluminum (bauxite) and certain ores of iron (hemitite and limonite) are found in abundance here. The base minerals are almost void making this soil very poor and in some cases close to being sterile. Surprisingly though, these soils are responsible for the most prolific vegetation found anywhere on the earth. I am speaking, of course, of the tropical rainforests.

The down percolation of minerals through the soil (leaching) due to the excessive amounts of heat and humidity force the roots systems of trees to be rather shallow. As plant and animal matter rots, the roots absorb the minerals being released thus explaining how plants can grow so profusly.

A very dense covering known as a canopy protects the soil from the exposure to the sun. If this canopy is broken and sunlight is allowed to penetrate, the ground is literally baked into an extremely hard brick-like substance known as laterite or duricrust. In other words, what nature has developed here is a very delicate balance which must be maintained if the continued existance of the rainforest is to be.

Occuring in the cool and humid climates where leaching too is prominent, but not as severe as in the tropics, a process known as podzolization develops. The base minerals are present here but a pure concentration of iron and aluminum is absent. An accumulation of humus in the upper portions of the soil rots which produces an acid making the soil poor. The acidity of the soil has a tendency to increase with the presence of coniferous trees. No hard duricrust forms and the color of the soil is an ash gray which reflects the abundahce of base minerals.

The gleization process of soil development occurs in poorly drained areas such as swamps, bogs and marshes. Where standing water exists, aerobic bacteria (that which breaks down plant and animal life outside of water) cannot survive. The decay of vegetation is very slow producing very thick layers of heavy soil known as peat. Peat ranges in color from a blueish gray to a black. Known as gley soil, it can be found in heavy concentrations in Florida around the swamp and marsh areas of the Everglades.

Developing in the semi-arid or sub-humid areas of the earth is a process known as calcification. Calcium is very wide spread and often collects on the surface. Due to the fact that leaching is almost non-existant, the topsoil has an exceedingly high concentration of the base minerals. Called caliche, these are the world's richest soils and are found beneath the grassy plains of the middle latitudes mainly.

Lastly is the process known as salinization. This soil developes in the poorly drained desert regions of the world where various salts accumulate in low spots. Large areas can be found in the western portions of the United States and Southwestern Asia around the Caspian and Dead Seas.

VEGETATIVE REGIONS OF THE WORLD

As was the intent, our discussion of the environment and how plants adapt themselves to their surroundings has led to this final section on the vegetative regions of the world. Looking back to the section previously discussed pertaining to the vegetative biomes, we are going to now analyze each one and the type of vegetation within.

FOREST BIOME

'Tropical Rainforest'

The forest biome consists of 6 different forest communities all located within a wide range of environments. Beginning with the tropical regions of the earth, we find the tropical rainforests. The climate of this region is rather precise in that the average temperature of every month never falls below 64.4 degrees F and each month gets at least 2.4" of rainfall. The soils are formed from the laterization process as a result of the exceedingly warm and humid conditions. The forest consists of tall, broadleaf evergreen trees located in rather close proximety to one another. This closeness produces a canopy which keeps the floor of the forest in perpetual shade. Smooth barked and unbranched in the lower portions of the trunk, these trees often have butressed roots located close to the surface due to the neccessity of aquiring minerals from the rotting plants around them, and simply to evenly balance the tall structures.

The rainforest region gives us many products of which we have grown accustom to using. Rosewood, ebony, mahogany and teak are exceedingly durable woods used in the making of furniture. From the Heava brasiliensis tree, the products of rubber and latex are aquired. Quinine, the drug used in the treatment of malaria and circulatory disorders within the blood, is obtained from the sap of the Cinchona tree. Cashew nuts are the seeds of the cashew apple which grows on a vine related to the poison ivy family. Manioc (a member of the potato family from which we get tapioca),

cacao (the plant which yeilds chocplate), chickle (the basic ingredient in gum). pepper (from the pepper berry) cinnamon, pineapple, coconuts, and bananas comprise a list of the rest of the most widely used products obtained from this very prolific region.

'Monsoon Forest'

The monsoon forest is located in the tropical regions of the earth and basically consists of broadleaf trees with a broken canopy. The broken canopy is the result of specific climatic conditions existing here. Not all tropical climates are like the rainforest regions. The monsoon forests experience a dry season caused directly by a seasonal reversal of pressure cells. As the pressure cells shift, so do the winds. From the months of May through October, winds originate over large bodies of water and flow inland carrying moisture laden air. These summer rains are usually quite intense and consistant.

From the months of October through May, pressure cells reverse their positions and winds then originate over the large landmasses. As the air flows towards the sea, the winds are very dry causing the broadleaf trees to enter a dormant state and shed their leaves. With the canopy open, sunlight is allowed to strike the forest floor. Keep in mind that the soil of the monsoon forest remains saturated enough to support tropical rainforest vegetation even though it experiences this dry cycle.

Stimulated by sunlight, a very dense ground cover begins to form on the forest floor creating what is known as a <u>jungle</u>. If not for the open canopy, this type of vegetation would not exist here. Monsoon forests are found to a large extent in southern and southeastern Asia.

'Temperate Rainforest'[8]

Interestingly, the tropics are not the only climate which spawn rainforests. With the key climatic element being rainfall, another area located in the middle latitudes also exhibits this type of vegetation. Temperatures. due primarily to latitude and altitude, are considerably milder creating a different type of plant community. The best way to explain this is by examining one specific rainforest located on the Pacific northwest coast of the United States.

The Olympic Rainforest is situated on the windward side of the Coast Range mountains west of the Puget Sound on the Olympic peninsula within the state of Washington. Just off of the coast of this vecinity flows a warm ocean current known as the Japan. The prevailing westerly winds dominate this area and flow across these warm waters bringing warm moist air inland. As this moisture laden air comes into contact with the mounatins, it is forced to rise which causes it to cool and eventually reach its dew point(that critical temperature upon which moisture condenses). As clouds form, they too are forced to rise up the side of the mountain. As their temperatures drop, so does their capacity to hold water. Eventually the saturation point (point where a cloud can no longer hold anymore water) is reached and precipitation begins. This type of precipitation which is influenced by the presence of a mountain is called orographic precipitation and is responsible for some very heavy amounts of rainfall at times. For these reasons, the Olympic Rainforest receives upward to 140" of precipitation per year.

The forest is a true mixed forest in that both evergreen and deciduous trees thrive here. The evergreen trees basically fall into two specific catagories, the Douglas fir and the Western hemlock. The Douglas fir reaches an average height of around 250' with a diameter at the base of the trunk of 6'. The Western hemlock has an average height of 175' with a trunk diameter of 4'. Because of their great heights and conical shape, enough sunlight can be absorbed allowing the trees to

survive. The deciduous trees, on the other hand, grow shorter than the evergreens but still can spread their branches enough to receive an ample amount of life giving sun.

The area is heavily enshrouded with an advection type of fog which moves in off of the sea. This fog greatly restricts the amount of evaporation which takes place and keeps the rainforest in a perpetual state of dampness and covered with moss.

As with all ecosystems (communities of the living and non-living parts of an environment and how they relate to one another), food chains rapidly develop. Being the Olympic Rainforest is prolific, let's take some time and discuss this very important part of any environment. Known as the trophic pyramid, this food chain consists of 5 different levels of life all owing their total existance to the sun.

On the bottom of the pyramid is a group of plants known as autotrophs. Mostly green in color, these plants owe their total existance to their ability to convert sunlight into food energy (photosynthesis).

Directly above the autotrophs is a group of plants which cannot get any nutrients from the sun. Heterotrophs feed directly off of the decaying remains of autotrophs. Fungi, mushrooms, etc. are all members of this catagory.

With the advent of the third level of the pyramid, the animal kingdom makes it's debut. Herbivores are those animals which feed directly off of the plant life in the area. Elk, deer, rabbits, squirrels, slugs, etc. are all examples of herbivorous animals.

The top two levels of the pyramid are interchangeable and consist of carnivorous and omnivorous animals. Carnivores are animals which eat only meat. Snakes, owls, hawks, eagles, etc. all eat only meat. Omnivores, on the other hand, eat both meat and plants. Bears are a prime example of omnivorous animals.

Aside from being a food chain, the trophic pyramid of the Olympic Rainforest, or

anyothe ecosystem as far as that is concerned, balances out the population of the various species of plants and animals existing there. If anything disrupts this very fragile balance, the ehtire community is affected.

'Mid-latitude Deciduous Forest'

The mid-latitude deciduous forests of North America, South America, Europe and Asia consist of tall broadleaved deciduous trees which form a continuous and dense leaf canopy. Ample amounts of sunlight are, however, allowed to penetrate to the forest floor and generate shrub and herbacious layers.

These forests experience both the calendar and actual changes of the seasons. During the fall, as the temperatures begin to drop, trees begin to go into a dormant state eventually shedding all of their leaves. During the spring, as the temperatures begin to warm up, trees once again sprout new leaves and flowers.

While it is true temperatures are the most obvious cause of trees entering into a dormant state, drought conditions will also create the same result. It is not uncommon that during a summer drought many trees shed their leaves to protect themselves from such adverse climatic conditions.

'Needleleaf Forest'

The coniferous (cone bearing) forests consist of conical shaped trees with straight trunks and needle shaped leaves. The are located in close proximity to one another and due to their lower portions being spread out, the amount of vegetative life on the forest floor is sparse.

Seven distinct types of needleleaf forests thrive around the world ranging from the high latitudes of North America, Europe and Asia to the lower latitudes of certain tropical areas.

Located between 45-75 degrees north of the equator are two types of <u>boreal forests</u>. These regions are primarily inhabited by trees such as the spruce, the fir, the pine and the larch trees. Conditions are so severe in certain areas of Soviet Siberia, some of these needleleaf trees are stunted and grow rather small. They are very close to the timberline here.

Extending into the lower latitudes where mountain ranges and high plateaus are found lives the needleleaf evergreen forest. While it is true these forests are located within the tropical regions of the earth, altitude prevents the temperatures from becoming too warm.

Perhaps the most amazing forest existing anywhere is the coastal needleleaf evergreen forest. These towering sentinels known as redwood trees grace this region and literally separate it from any other. Due to the geographic make up of the North American continent, the Pacific northwest coast is blessed with tremendous quantities of rainfall resulting from orographic precipitation and high amounts of humidity. Nowhere in the world do redwood trees grow to these heights.

The lake forest, which consists of White pines, Red pines and Eastern hemlocks are synonymous with the regions around the Great Lakes of North America. The diurnal winds influenced by the differences in temperatures between the land and the lakes are quite influential in the physical set up of this ecosystem.

The southern pine forest is unique to North America and is found in the sandy soils of the southeastern coastal plains. The porosity of the soil makes rainfall in large amounts very beneficial. It is not uncommon, however, for drought conditions to exist, especially in Florida.

Lastly, the extremely large forested area which is the northern most range of the boreal forest is called the taiga. A very cold sub-arctic climate (average temperature of the coldest month is at least a -36.4 degrees F.) is responsible for the stunted growth of the trees and the reason they are spread so far apart.

'Sclerophyll Forest'

The sclerophyll forest is an open forest woodland with a canopy covering of only 25-60% of the area. Closely associated with a Mediterranean climate, this forest is primarily found on the western coastal regions between 30-45 degrees north and south of the equator. The summers are extremely dry with most of the rainfall coming in the winter. Shrubs as well as trees have sparse canopies. The cork oak and the eucalyptus trees are prime examples of the types of trees which grow in this environment.

GRASSLANDS BIOME

In the areas of the world where rainfall is in the moderate range, mesophytic vegetation prevails. Mesophytes are those plants which require only moderate amounts of water to grow. In general, grasses fall into this catagory. Differentiated by latitude, 3 basic types of grasses are found in the grasslands biome and are worth some discussion. The savannas, prairies and steppes owe their existance to the richness of the soils in these areas which are kept fertile by the lack of heavy precipitation which prevents leaching. Man has used these areas for large scale agricultural endeavors for many years because of the soils.

'Savanna'

In the lower latitudes, the ever present tall grass savanna exists as a transitional zone leading into the desert biome. Rainfall averages between 20"-40" per year with mean temperatures all being over 64.4 degrees F. The openness of these grasslands is very extensive with the presence of acacia and baobab trees dotting the countryside. During the wet season, grasses will grow to great heights which is why they are called "elephant grass". As winter approaches, however, rainfall diminishes as does the height of the grass.

'Prairie'

The prairie region of the earth is found in the middle latitudes where rainfall, too is around 20"-40" per year. Temperatures, however, are more extreme due to the fact these regions go through the actual seasonal changes. Plant formations of tall grasses (not as tall as the savanna) and forbs (broadleaf herbs) dominate the region. Prairies are predominently found in North America, Europe and Asia.

'Steppe'

Steppes or short grass prairies are also located in the middle latitudes. Receiving less precipitation per year (10"-20"), these grasses are much shorter the the prairie, bunched close together and sparsely distributed across the countryside. Located in

North America, parts of South America, Africa, Europe and Asia, large scale farming can be accomplished here with irrigation techniques put to use. Once again, because leaching is almost non existant, soils are very rich in the base minerals.

DESERT BIOME

'Dry Desert'

By analyzing a diagram of the general circulation of the earth's atmosphere, you will notice a particular wind system originating around the 30th parallel north and south of the equator. Refered to as the sub-tropical high pressure belt, this system is noted for the formation of clear skies and very little rain. It is here that most of the worlds deserts originate. Receiving less than 10" of rainfall per year, the plant life which develops is xerophytic by nature. Xerophytes are plants which require very little water and consist of widely dispersed shrubs and grasses, short lived annuals which appear sporatically and a perrenial shrub specie with small spiny leaves known as a cactus. Deserts are found on every continent with the exception of Europe and Antarctica.

'Semi-Desert'

As the name depicts, the semi-desert is not a true desert in that it receives more than 10" of rainfall per year but never more than 20". Scattered xerophytic shrubs with a sparse low herbacious layer is able to survive. This transition zone separates the grasslands from the desert and is located on every major continent with the exception of Europe and Antarctica.

TUNDRA BIOME

The last vegetative biome to be discussed is the one which is located just below the 50 degree F. isothermal line where "normal" tree growth stops. We find these regions either in the high latitudes or high altitudes of the earth where short stunted grasses grow. Being that the average temperatures never exceed 50 degrees F., several unusual environmental conditions exist which definitely influemce all life forms in general.

'Arctic Tundra'

The Arctic tundra is a treeless undulating plains area which borders the Arctic Ocean. Vegetation, in order to survive, must adapt to some very adverse conditions. Permafrost (permanently frozen sub soil) develops 6"-12" beneath the surface of the earth. Any material which remains in this frozen state for a period of 2 years or more is classified as such. The active layer, or that top 6"-12" which thaws once a year, produces an environment which is condu ive for the growth of flowering herbs, stunted grasses and some trees which grow horizontally due to the relentless winds. These plants must grow to their full maturity within a very short span of time, generally about 1½ months. Located in North America, Europe and Asia, this region is primarily situated north of the Arctic Circle where winter months last well beyond the calendar seasons.

'Alpine Tundra'

It has been said that one can experience as many different types of climates by scaling a mountain in certain regions of the world as would be possible by traveling from the equator to the North or South Pole. The same is true for vegetative regions. The Alpine tundra has plant formations similar to the Arctic tundra but is found above the limit of tree growth in the mountains where temperatures also never exceed 50 degrees F. Sometimes refered to as the Alpine Meadow, these biotic communities are located primarily in North and South America, Europe and Asia.

IV. SPECIFIC VEGETATIVE TERMS

ACTICE LAYER- THE TOP 6-12 INCHES IN THE TUNDRA SOIL WHICH ALLOWS LIFE TO GROW. THE TEMPERATURES WARM UP ENOUGH TO THAW THAT SECTION AND SUPPORT LIFE.

BIOLOGIST- THE SCIENTIST WHO STUDIES PLANT AND ANIMAL LIFE OF THE WORLD.

BOTONIST- THE SCIENTIST WHO STUDIES THE PLANT LIFE OF THE WORLD.

BROADLEAF TREE- TREES WHICH HAVE BROAD-FLAT LEAVES.
OAK, MAPLE, SYCAMORE, ETC.

CONIFEROUS- PLANTS WHICH ARE CONE BEARING. CONES ARE HARDY SEEDS.

DECIDUOUS- PLANTS WHICH SHED THEIR LEAVES ANNUALLY DUE TO COLDER TEMPERATURES AND OR DROUGHT CONDITIONS. PLANTS STOP GROWING. GO INTO A DORMANT STAGE.

DECOMPOSER- FACTERIA WHICH AIDS IN THE PHYSICAL BREAKDOWN OF PLANT AND ANIMAL LIFE. COULD ALSO BE INSECTS.
AEROBIC- FACTERIA WHICH ASSISTS IN THE BREAKDOWN OF PLANT AND ANIMAL LIFE ON LAND
ANAEROBIC- FACTERIAL LOCATED IN WATER WHICH ASSISTS IN THE BREAKDOWN OF PLANT AND ANIMAL LIFE

ECOLOGY- THE SCIENTIFIC STUDY OF ECOSYSTEMS

ECOSYSTEMS- THE COMMUNITY OF THE LIVING AND NON-LIVING PARTS OF AN ENVIRONMENT AND HOW THEY RELATE TO ONE ANOTHER.

ECOLOGIST- SCIENTIST WHO STUDIES ECOSYSTEMS

EPIPHYTE- TROPICAL RAINFOREST VINE WHICH USES OTHER PLANTS OF THE AIR ITSELF TO GROW. DOES NOT RELY ON THE SUN.

BROADLEAF EVERGREEN TREE- AN EVERGREEN TREE WITH BROAD-FLAT LEAVES

EVERGREEN TREE- A TREE WHICH CONTINUES GROWING YEAR ROUND.

HAMMOCK- AN ISOLATED PATCH OF TRUE TROPICAL RAINFOREST VEGETATION

LIANA- A TROPICAL RAINFOREST VINE WHICH USES OTHER TREES AS SUPPORT AS IT CLIMBS TOWARD THE SUN

MIXED FOREST- A FOREST WITH BOTH EVERGREEN AND DECIDUOUS TREES

NEEDLELEAF TREE- A TREE WITH NEEDLE SHAPED LEAVES
PINE, FIR, SPRUCE, ETC.

OROGRAPHIC PRECIPITATION- RAINFALL INFLUENCED BY THE PRESENCE OF A MOUNTAIN

PAMPAS- GRASSLANDS OF ARGENTINA

PERMAFROST- PERMANENTLY FROZEN SUBSOIL 6-12 INCHES BENEATH THE SURFACE OF THE SOIL. ANYTHING WHICH REMAINS FROZEN FOR A PERIOD OF 3 YEARS OR LONGER

PHOTOSYNTHESIS- THE ABILITY OF CERTAIN PLANTS TO CONVERT SUNLIGHT INTO FOOD ENERGY

PRAIRIE- MID-LATITUDE GRASSLANDS.

PURE STAND- A FOREST WHERE 1,2,OR 3 PARTICULAR TREE SPECIES DOMINATE AN AREA

SAVANNA- LOW LATITUDE GRASSLANDS

STEPPE- SHORT GRASSES USUALLY FOUND IN SEMI-ARID REGIONS

LICHENS- COLONIES OF FUNGUS AND ALGAE LIVING TOGETHER

TIMBERLINE- THE UPPER LIMIT OF TREE GROWTH

TROPHIC PYRAMID- A FOOD CHAIN FOUND IN EVERY ECOSYSTEM
AUTOTROPHS- PLANTS WHICH USE SUNLIGHT TO GROW
HETEROTROPHS- PLANTS WHICH USE OTHER PLANTS TO OBTAIN THE ENERGY TO GROW. FUNGI FOR EXAMPLE
HERBIVORE- PLANT EATING ANIMALS
CARNIVORE- MEAT EATING ANIMALS
OMNIVORE- ANIMALS WHICH EAT BOTH MEAT AND PLANTS

TUNDRA- TREELES GRASSLANDS LOCATED BORDERING THE ARCTIC OCEAN (ARCTIC) OR IN THE HIGHER ALTITUDES (ALPINE)

VEGETATION- AN ARRAY OF PLANT LIFE. PLANT LIFE OR TOTAL PLANT COVER

Questions for Assistance

Introduction-Environments: Systems of Adaptation

1. The total array of plant life is called _____.

2. Those features which surround us, influence us, and cause us to adapt make up our _____.

3. Our environment can be divided into 3 component parts. List them.

4. What does the term "inorganic" refer to when used in the context to describe the physical environment? How does it differ from that of "organic" as used to describe the biological environment?

5. Define the following:
   a. biosphere
   b. biocycle
   c. biome or biochore

6. List the 3 divisions of the Earth's biocycles.

7. List the 4 biomes of the Earth's land biocycle.

8. The role plants and animals take in adjusting to their surroundings is called _____.

9. Explain the concept of "natural succession."

10. What is a climax community?

11. List the two building blocks of adaptation.

12. How does climat influence the vegetative adaptation of an area?

13. List the 3 base minerals found within most soils which are neccessary for plant growth?

14. Distinguish between "rot" and "decay".

15. How does leaching influence the mineral content of soil?

16. List and describe the 5 soil developing processes of the Earth.

17. Define the following:
   a. canopy
   b. laterite or duricrust
   c. aerobic bacteria
   d. caliche

Questions for Assistance

Vegetative Regions of the World

1. Describe the climate of a tropical rainforest.

2. List several products obtained strictly from a tropical rainforest which must be imported into the United States.

3. Why if the forest floor of the rainforest in a state of perpetual shade?

4. Why is the canopy of a monsoon forest broken at certain times of the year? How do the monsoon winds produce this effect?

5. What is a jungle?

6. Describe the geographic and climatic conditions existing on or near the Pacific Northwest coast of the contiguous United States which creates the temperate rainforest existing there on the Olympic peninsula.

7. Draw, label, define, and give one example for each level of the trophic pyramid.

8. Describe the term "deciduous" as it applies to the mid-latitude deciduous forest and tell what climatic conditions exist creating this ecosystem.

9. Define the term "coniferous".

10. List and describe the 7 various types of evergreen forests.

11. Grassland vegetation is said to be mesophytic. What are mesophytes?

12. List and describe 3 types of grasslands found around the world.

13. Desert vegetation is said to be xerophytic. What are xerophytes?

14. List and describe 2 types of desert vegetation.

15. Define the following:
    a. arctic tundra
    b. permafrost
    c. active layer
    d. alpine tundra

16. Describe tundra vegetation.

INTRODUCTION TO FRESHWATER RESOURCES

Consider for one moment just how much water there is on the entire planet. Being the Earth primarily consists of this precious resource, such a task may seem highly improbable, but not totally impossible. The following facts may simplify or help organize your thoughts somewhat:

- -there are approximately 326 million cubic miles of water found in the earth's oceans basins
- -of all of the earth's waters, that represents about 97%
- -2% of the earth's waters have been temporarily removed from the hydrologic cycle and are concentrated in glacial ice (freshwater)
- -this leaves a total of 1% which remains available for human consumption
- -that 1% is found in the freshwater surface features of the earth as well as in the ground

What remains rather amazing about these figures is the obvious complacent attitude we have towards the use and preservation of what water we do have. The main objective of this unit will be to explore:

- -The Global Moisture System
- -Fresh Surface Waters
- -Problems of Water Consumption

THE GLOBAL MOISTURE SYSTEM

As mentioned in the introduction, most of the earth's waters are located in the oceans basins. Every year, approximately 80,000 of the 326 million cubic miles of saltwater is evaporated. Cooling and then condensing, this water changes it's state forming clouds. From here, as precipitation develops, 56,000 cubic miles of freshwater annually falls back over the oceans. Carried by the winds, the remaining 24,000 makes it's way to the landmasses. At this time, one may ask, "At what point did the saltwater change into freshwater?" Simply put, the answer lies at the point of evaporation. The minerals dissolved within the saltwater of the oceans are left behind as the water changes it's state. This natural process by which saltwater is changed directly into freshwater is called distillation.

'Properties of Water'

What seems rather amazing is the number of items we have a tendency to take for granted or not give a second thought which can have their roots traced directly back to nature. The simple fact that ice floats is the result of the expansion of water upon freezing. With the total volume increasing another 9%, the ice now has a broader base giving it the ability to displace more water, thus giving it buoyancy.

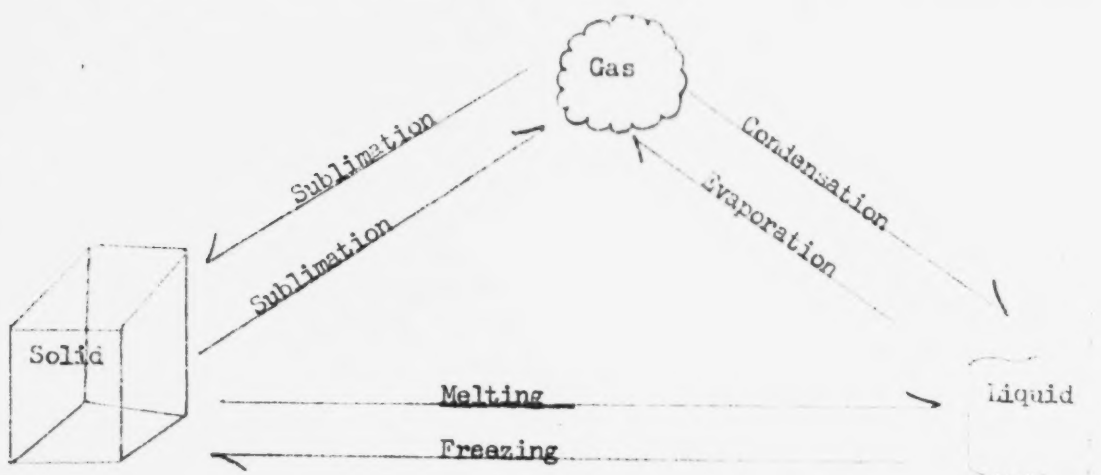
Observing the forces of erosion and the affects it has upon the earth is another example of not giving something nature has provided us a second thought. Of the 3 erosive forces (wind, water and ice), water does the most destructive damage in such a short period of time. Because water moves by the force of gravity flowing along the path of least resistance, it is very easy to trace it's path across the countryside. Along this path, anything of natural origin in the physical environment will be dissolved and relocated elsewhere given enough time. This can radically alter the appearance of the earth. The total affect moving water has upon the earth will further be explained when the section pertaining to rivers and streams is discussed.

The climatic factor of water is displayed in the fact that water has the ability of retaining it's heat for extended periods of time. People living along the coastal regions of the earth are obviously affected by this trait, but, don't seem to be aware of the reasoning behind it. Being that water is transparent, sunlight is allowed to penetrate the surface heating as much of the volume as the depth permits. By taking longer to absorb the heat, it also takes longer to release it. Solid surfaces, however, are quite different. Only the surface area of solids is directly affected by the sun. With less to heat, solids logically loose their temperatures faster. Land is a good example of this.

By contrasting thie differences in the heating of liquids and solids, it should be easier to understand how large bodies of water when accompanied by local winds, have a profound affect upon the temperatures of the lands adjacent to them. This is especially obvious in the low and middle latitudes.

'States of Water'

Scientists tell us water occurs naturally in 3 different forms or states with the capability of changing from one to another. If the water is such that it can expand easily to fill any small container, it is said to be a gas. That which responds freely to unbalanced forces is called a liquid. If the water resists change in both shape and volume it is refered to as a solid. What causes these changes of state can best be clarified by examining the following diagram in conjunction with a detailed explanation.



In certain areas of the world where temperatures are very cold (i.e. the high altitudes and high latitudes), water in the form of a gas will change directly into that of a solid and then settle. Primarily due to a decrease in temperature, this can best be illustrated by observing how frost collects around the frozen foods in the freezer compartment of certain refrigerators. This process is known as sublimation and begins with moist air in the atmosphere of the freezer.

By the same token, the reverse process also takes place. Water in the form of a solid will change directly into a gas. Once again, due to convenience, let's go back to the freezer and see if this can be observed. Have you ever noticed what appears to be a "cloud" or "steam" come out of the freezer and dissipate as you open the door? What you were witnessing was this change of state also known as sublimation. The process can be directly observed by placing a small container of water in the freezer and allowing it to freeze. Upon freezing, notice the approximate volume of the ice and then leave it for a period of one week. When next observed, you will notice that the volume in the container has diminished. If allowed to stay in the freezer unhampered, it will eventually disappear. The process at work here involves an increase in temperature.

As the temperature increases above the freezing mark, water in the form of a solid changes to that of a liquid. This process is called melting and is for the most part responsible for the increase in sea level around the world. Under normal conditions, the polar ice caps are melting enough to supply the greatest portion of the 1" of new water to the oceans every 100 years. Since 1900, however, 5" of new water has been added to the earth's seas. What is causing this unusual rate of melting is still being debated.

When water in the state of a liquid changes to that of a solid, freezing occurs. This is accomplished by lowering the temperatures below the freezing point. Aside from the ice cubes found in your freezer, this natural state of water is

primarily located in the glacial regions of the world. This is not to say that ice does not form on any other body of freshwater because obviously it does. However, most of the earth's ice is found in the polar regions.

Evaporation occurs when water in the form of a liquid changes directly into that of a gas. The largest amounts take place in the tropics where warmer temperatures are responsible for the placement of large quantities of moisture into the earth's atmosphere.

To complete our discussion of the processes of change, condensation takes place when water in the form of a gas is changed into a liquid. This happens in the upper atmosphere where the water cools below the dew point (that critical temperaturs below which moisture condenses) and forms around tiny dust particles called nuclei thus forming clouds. To bring this closer home, how many times have you set a cold drink on a table without a coaster or a pad? As time progresses, you notice water drops collecting around the drink and flowing onto the table leaving a water ring around the drink itself. What has happened is that the moisture in the room's atmosphere came into contact with the cool container thus condensing around it. The container actually became the nuclei neccessary for the water to complete the condensation transformation.

'Hydrologic Cycle'

Almost all elementary children are taught the basic principles behind the earth's hydrologic or water cycle. By simply skimming the surface, the student theoretically comes away with a rudimentary understanding of how water is transported and deposited around the earth's surface. Our purpose in this section will be to take a more detailed approach by examining the 4 phases the cycle progresses through. These phases are evaporation, condensation, precipitation and infiltration.

During the evaporation phase, water from the surface features of the earth is transformed into a gaseous state and carried aloft. The following is a list of areas from which evaporation occurs:

-from falling precipitation

-from vegetation

-from soil

-from transpiration

-from fresh surface waters

-from the oceans

Upon first glance, it becomes quite obvious that the largest percentage of the earth's evaporation takes place over the oceans. Individually, however, the other 5 areas are of equal importance in the distribution of water around the globe. Collectively, their significance is even greater. When combined, evaporation from soil, vegetation and transpiration (when a plant actually releases water) becomes the largest single contributor of moisture to the atmosphere over land. Known as evapotranspiration, the greatest amounts occur over the heavily forests regions within the tropics.

During the second phase, moisture in the gaseous state cools as it gains altitude. Having reached the dew point, condensation will occur provided there is something in the atmosphere for the moisture to condense around. At this stage, clouds form and the second phase of the hydrologic cycle ends.

The third phase concerns the method by which the moisture in the clouds is returned to the earth. This is a process known as precipitaion and takes place when the clouds saturation point (that point at which the cloud can no longer hold any more water) is reached. Just what that point is depends upon the clouds ability or capacity to hold water and capacity is directly related to temperature. Generally, the warmer the air, the greater is it's capacity to hold water. This is why thunderstorms predominently take place during the warmer times of the year. Once precipitation begins, it occurs naturally in the forms of rain, sleet, hail and snow. Upon striking the earth, this third phase ends.

Water which is not evaporated, nor runs off into the fresh surface waters, but instead is infiltrated into the ground becomes known as groundwater. During this fourth phase,

we will follow the path of water as it is carried by the gravitational forces through the earths crust. Commonly refered to as infiltration, this is that point when water actually penetrates and enters the ground. Upon close examination, we find groundwater being channeled to one of 7 different locations:

-into the roots of vegetation

-into the soil

-into the fresh surface waters

-into the oceans

-into karst features

-into geothermal pockets

-into fossil waters

For the most part, it is not difficult to understand how the final phase of the water cycle is completed. Water which is absorbed into the roots of vegetation will eventually be drawn up the plant and through natural processes, evaporate back into the earth's atmosphere. Groundwater located in the soil also works it's way out evaporating and returning to the atmosphere.

Following the course of groundwater in the discussion of karst features and geothermal pockets involves much more detail, however. As the old expression goes, "You can't tell the players without a program", you will not be able to understand the explanation of how these groundwater features develop without a basic explanation of a few key terms.

1. karst- the topography of any limestone area where sinkholes are numerous and small surface streams are nonexistent.

2. calcium carbonate- mineral found in both limestone and dolomite

3. carbonic acid- a weak acid produced when water is mixed with calcium carbonate

4. caves- an erosional feature by which water has cut the sub strata of rock (usually limestone) creating a passage or hollow beneath the surface

5. cavern- a large cave

6. sinkholes- the collapsed roof of a cave or a cavern which causes the ground above to also collapse

7. geothermal- steam heat from the earth

8. porosity- the volume of open spaces in rock and soil

9. permeable- any porous substance which not only holds water but also allows it to flow through it

10. impermeable- any non-porous substance which will neither hold water nor allow it to flow through it

11. aquafer- a permeable rock layer

12. aquiclude- an impermeable rock layer

13. caprock- an aquiclude sitting on top of an aquafer not allowing the heated water trapped inside the aquafer to escape to the surface

14. fumarole- a crack which develops in the caprock as a result of the build up of pressure from the heated water in the aquafer. The water is thus allowed to escape to the surface

15. geyser- an intermittent hot springs or fountain from which hot water or steam is issued

16. hot springs- pools of hot water on the surface of the earth coming up through fumaroles

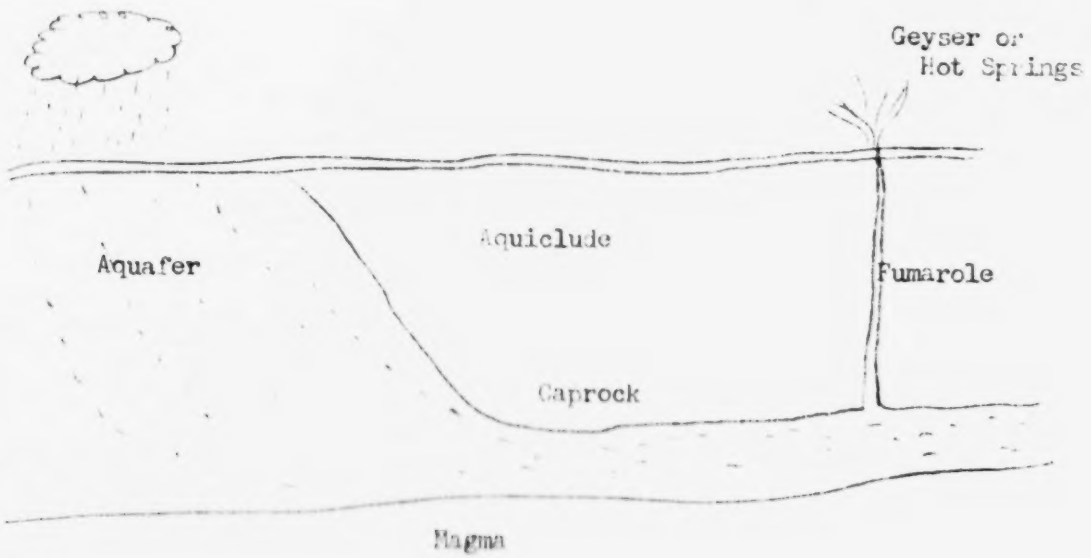
17. magma- molten rock material inside the earth

18. fossil waters- miute quantities of water trapped in rocks through geologic activity

Beginning with karst features, as groundwater flows through limestone, it mixes with the basic mineral of calcium carbonate making a weak acid known as carbonic acid. As the carbonic acid dissolves the limestone, water can then begin to flow freely. Eventually the karst features of caves, caverns and sinkholes emerge. As the water continues flowing, it will be absorbed into the other groundwater features, or end up out in the open where the infiltration process will come to an end. Regardless, the cycle will begin once again.

Geothermal pockets exist along old or new plate boundaries where sources of magma can be found. As water is absorbed into the earth, it flows through aquafers deep into the earth where it comes into contact with magma reservoirs. Situated directly above the moisture laden aquafer is an aquiclude acting as a caprock. Due to contact with

the magma, the water trapped in the aquafer reaches very high temperatures which in essence creates tremendous amounts of pressure as the water look for a route upward. This route comes in the form of a fumarole. As hot water from deep inside the earth is forced to the surface, the infiltration phase of the cycle once again comes to an end. The following diagram depicting the development of geothermal waters will assist in this explanation.



The last area groundwater could possibly be channeled into is what is known as fossil waters. Minute quantities of water become trapped in sub-surface rock as it is subducted or pushed deep into the earth. This water is then removed from the hydrologic cycle for a period of many years. Only when the movements of the earth once again bring this rock strata up to the surface will the water trapped in it be released into the earth's atmosphere again. At this point, the cycle will begin anew.

FRESH SURFACE WATERS

The property of water mentioned earlier pertaining to it's ability to dissolve anything of a natural origin in due time lends itself to a closer examination at this time. As water flows across the countryside, not only does it begin to dissolve those parts of the earth it comes into contact with, it also loosens that material and assists in it's relocation. The techniques of relocation are transportation and deposition. Transportation occurs when the loose unconsolidated material is actually moved to a different location by the forces of erosion (in this case water). Either due to the forward motion of the erosive agent diminishing, or something literally blocking it's path, the transported material will eventually become relocated. When this happens, the process of deposition is complete.

Water erosion goes through four distinctive stages ranging from that which is very minimal to that which is very destructive. These stages are sheet, rill, gulley and badlands. Remembering that water follows the path of least resistance, as it first begins to move across the earth, it flows in sheets carrying loose material with it. Once the "low spots" have been determined, water begins to carve out small paths as it's flow takes on a definite direction. This is refered to as the rill stage.

As the rill stage continues and these paths become more pronounced, the gulley stage take over. Streams and rivers become the most obvious features of this stage.

The final stage of water erosion is found only where the earth has experienced a tremendous influx of water over an extended period of time. Generally located in areas where continental glaciation has taken place, it is during the inter-glacial warming trends that enough water can be supplied to create this particular type of water feature. As the area remains in a perpetual flood stage for countless numbers of years, the landscape become greatly altered as the result of transportation and deposition. This particular erosional feature is known as a badlands.

Understanding the affects flowing water has upon the earth's surface will better enable you to grasp the concepts of rivers and their development.

'Rivers'

Rivers are long narrow paths of freshwater flowing across the countryside. To those who live in river valleys, the effects of stream erosion becomes a major factor in the overall development of their physical environment. Providing excellant sources of freshwater, almost all major settlements can be found along or close to these intrigal features. Just where do these rivers originate? What uses do people have for them? What affects do they have upon the surrounding land areas? The answer to these questions will be closely examined in the following sections.

Rivers originate in one of five different areas of the earth. The most common is the result of snowmelt from mountains. Most of the major river systems of the world owe their existance to this source including the largest of all, the Amazon. While the Nile River of Northern Africa is 125 miles longer, relatively speaking it is a mere trickle of water in comparison. Originating in the Andes mountains of Peru, the 4000 mile long course takes it through the tropical rainforest regions of Brazil eventually emptying into the Atlantic Ocean. With an average width of 7 miles, the flow of the Amazon carries freshwater 100 miles out into the Atlantic. Ocean going vessels travel several hundreds of mile upstream to the city of Manaus, Brazil indicating the depth of the Amazon up to that point must be quite deep. Comparatively, no other river in the entire world is in the same catagory as the Amazon.

The confluence of two smaller streams is the second source of rivers. This is the point where two rivers actually flow together. The point of convergence is called the confluence. As we look around the world, many examples of this particular source can be sited. In the United States, the confluence of the Allegheny and the Monongahela rivers form the Ohio. In the country of Sudan in Africa at the city of Khartoum, the Blue and White Nile rivers join to form the Nile.

Underground springs, lakes and glacial melt round out the three remaining sources. While these are of lesser significance in the development of the major systems, they are, none the less, of equal importance in the overall development of life in the river networks.

Rivers are used for a variety of different reasons all lending themselves to the development of wants and desires. Before examining these uses, I would like to differentiate between the terms use and consume. While both are classified as uses, to consume refers to the actual removal of the water from the source without directly returning it. To use is just the opposite. This water is removed, used for what ever purpose it was intended, and then returned to the source. The following uses of water display both characteristics.

Initially, the domestic and municiple uses of water are the most important. The term domestic refers to those basic needs of drinking, bathing, washing clothes.....etc. While we take this particular use for granted in many cases, it is the most sought after in the sustenance of life.

Moving from individual to community uses, the term municiple comes into focus. If you take the total amount of water used during the course of one day in any community and divided that total by the population involved, the end result would be the per capita usage. This average number often times reflects the cities affluence.

Water is the chief resource neccessary for industry to function. Without it, production would inevitably cease. Yet, as is usually the case, one of the major contibutors to pollution in lakes and rivers is industry. Simply acknowledged as a matter of finance, it is cheaper to allow the natural flow of the river to carry waste products downstream from the factory. Thankfully, the world communities are beginning to monitor what can and cannot be deposited into our river systems today.

In an era of energy conservation, the non-renewable fossil fuels of coal, natural gas and petrolium are being replaced by other means of producing electricity. One such method is the use of water power or hydroelectricity. By using the force

of the water to generate the electricity, those cities located on the banks of rivers can exist in an environment where there is no major concern of possibly running out of fuel.

Those regions of the earth which are climatically classified as either sub-humid or semi-arid are, in many instances, quite capable of supporting large scale agricultural endeavors if only enough water can be supplied. By bringing water into an area of need, irrigation can greatly assist in the production of additional food neccessary for all cultures. When normal irrigation techniques are put into practice, water is generally consumed in enormous quantities. As a result, the need for conservative methods used by farmers who use irrigation is of vital importance. The ultimate goal is the production of as much, if not more, food with the consumption of less water.

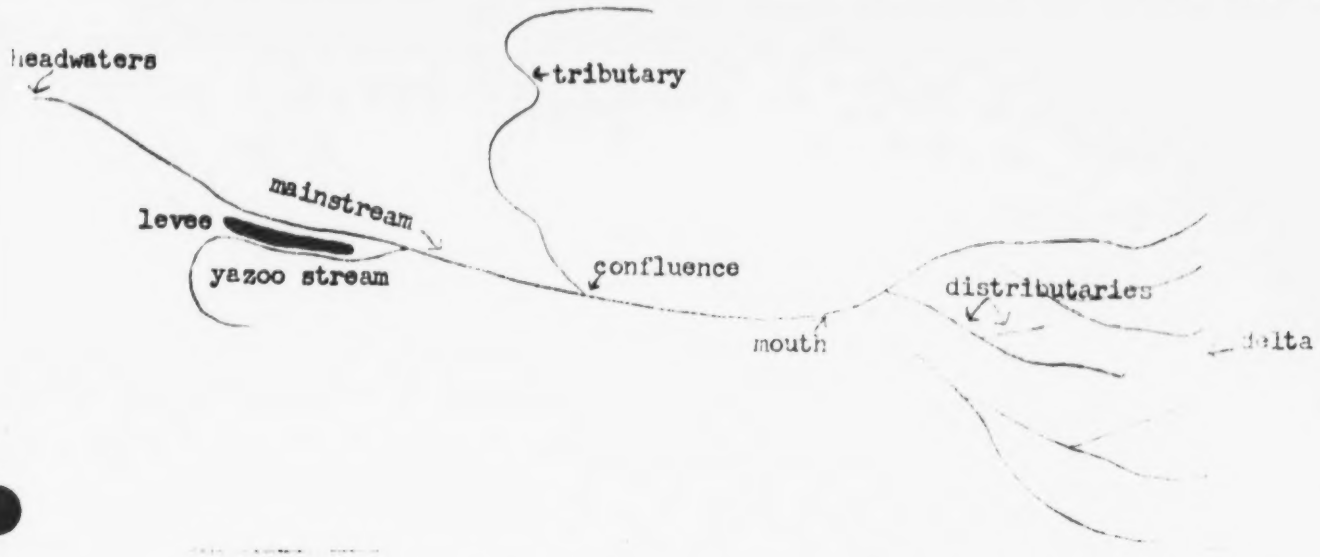
The scenic and recreational aspects of water in conjunction with transportation offer the people of those areas opportunities which are non-existant in other places. Aesthetically, there is probably no other place with a more tranquil setting for pure visual relaxation than Lake Louise. What nature has given us here certainly epitomizes the essence of beauty with this glacially fed lake located in Alberta, Canada.

In addition, the industrial use of river systems as linkages to other ports has long been established. Dating back many years, one of the first methods of moving goods and services around a country was on the rivers. These natural highways have long been sought after as a way of spreading commerce as well as culture.

Lastly, water is being used as a means of disposing our waste products through treatment plants. What is now becoming a major problem, our present day concerns should definitely be channeled towards a method of returning this water in a clean manner to the rivers or lakes from which it came. In this way, the natural environments depending upon this water could continue to exist in a more harmonious state.

'Physical Features Associated With Rivers'

In order for one to totally understand the overall development and affects rivers have upon an area, specific features generally associated with these streams must be identified as well as discussed. The following diagram will assist as a visual representation of the types of landforms normally found along the channel itself.



As the mainstream of a river flows through an area, the diagram refers to two smaller streams entering the channel at different locations. While both are contributing water to the mainstream, thus becoming tributaries, one is separated from the channel by a levee along certain portions of the river. The levee, a natural floodwall, prevents the one from entering the main channel forcing it to flow parallel to it until a break is found. At this point, the stream is allowed to enter the main channel becoming a special type of tributary known as a yazoo stream. That point at which the two streams converge forming one is called the confluence of a stream.

The point of origin of all rivers is called the headwaters. At the opposite end where it empties into a larger body of water, it is refered to as a mouth. If conditions are right, as the velocity of the river slows down, materials, such as silt and sediment which are being transported, are deposited thus beginning to collect or build up at the rivers mouth. The river then begins to branch out into different directions

forming a triangular depositional feature called a delta. Being that the ancient Greek symbol for a triangle was their letter delta, the reasoning behind this river symbol being named as such makes sence.

Branches of the mainstream located in the delta are called distributaries. It should be noted at this point that all parts of the river systems are of vital importance to the ecosystems of those areas involved. The more we know about these features, their chances of preservation become even greater.

'The Chronological Development of Rivers and Streams'

The mark rivers leave as they flow through an area changes with time. These changes or phases each have their own characteristics which are distinguishable as well as predictable basically because the ultimate goal of all rivers is to flatten out any and all irregularities they come in contact with. Due to these irregularities, a stream will most likely be at different stages of development the farther upstream one travels.

The initial stage is known as early youth. During this phase, an overland flow of water created by precipitation is basically concentrated in areas where the slightest depressions exist. Stream channels thus develop as well as small lakes where depressions fill up. As the flow of the water continues, the channels deepen. While following the path of a stream in this phase, one will find rapids and waterfalls in addition to lakes. Rapids occur in areas where the channel either narrows or changes elevation rather abruptly. In either case, the velocity of the stream increases as the volume of water is being pushed though the same openning. Waterfalls occur where the river actually flows over a steep embankment.

The length of time it takes to complete this phase, or any other phase as far as that's concerned, depends upon the material the water must cut through. Water erodes permeable materials faster than impermeable ones.

As the river continues cutting down through the channel, it eventually enters the

second phase known as late youth. Lake outlets are cut through draining the lake and extending the stream across the old lake floor. Waterfalls are cut down until nothing is left but rapids while the original rapids eventually disappear all due to the erosional forces of the flowing water.

When the initial stage of rapid downcutting ends, the stream begins to smooth out reaching a point known as equilibrium. This early maturity stage is characterized by the streams lateral movement. Refered to as meandering, the velocity of the flow, as the river moves around a bend, cuts or erodes the outside portion of land transporting that loose material downstream to the inside of the next curve depositing it at that point. This strip of relatively flat land located on the inside of a bend is called a floodplain.

During the fourth phase or late maturity, the floodplains assume a more vital role as a productive belt usually occupied by a large number of people. As meanders become fully developed, the river will eventually cut back actually meeting itself. When this happens, an ox-bow pond or lake develops as the meander loop becomes separated from the mainstream.

Given enough time, The river enters the final phase of it's development known as old age. With broad floodplains and fully developed meanders, the river strives to reach the goal of base level. For the most part, base level is an imaginary inland extension of sea level. Theoretically, as the river empties into an ocean or sea, it will stop cutting down into the earth. The flattening of the stream proceeds from the mouth back upstream to the head. Once again, the river in all probability, exists in several different phases of it's development all at the same time.

Base level is also attained at the point where a river flow into a larger stream or inland body of water. When the forward progression of the river is inhibited, downcutting will only progress at the rate of the other body of waters pace. In the case of a large lake, the downward progression of the stream basically stops.

As should now be apparent, rivers dramatically alter the landscape of a region creating intricate ecosystems as they move through their different phases.

'Ponds'

People initially learn by a process known as "sight association". From the time we are infants, we are shown objects and then told what those objects are. After the process is repeated several times, we begin to associate the name of the object with the object itself. A problem arises, however, with this method of learning. H ow do we put into words those visual objects when asked to describe them. While the sight association process has many advantages, if we don't learn how to verbally describe while learning, something is definitely lacking in our thought processes. I'm sure that when I mention the term pond, everyone is able to conjure up a mental image of what one locks like. The question is, can you describe it? In this short section, our purpose is not simply to describe the pond, but also to relate it's relevance to the environment as well.

A pond is a small enclosed body of freshwater smaller than the total volume of a lake, yet shallow enough to allow sunlight to strike the floor. The sunlight stimulates the process of photosynthesis thus allowing plant life to grow throughout. Because of this plant growth, the pond is a temporary fixture upon the surface of the earth.

While nature is responsible for the creation of five different types of ponds, man has developed one. The kettle pond was formed as the result of continental glaciation as huge blocks of ice buried in ground moraine were left behind as the glaciers receeded. The meltwater in addition to the remains of the blocks of ice filled the depressions left by the sheet of ice.

Located in the floodplains of rivers are depressions fed by the floodwaters of the rivers themselves as well as by the watertable. These ponds are known as cyprus ponds.

Another pond associated with rivers is the ox-bow which, if you recall, is the cut off portion of a meander loop. As with most ponds, the watertable is instrumental in supplying the water keeping this pond from drying up.

The type of pond actually built by the little beaver is formed when a section of a river or lake is dammed up thus separating it from the rest of the main body.

The karst pond forms when a natural sinkhole fills up with water and is maintained by the underground stream which created the formation in the first place.

The final pond is not natural. Gouged out by heavy machinary, the farm pond is primarily used to water livestock as well as for irrigation purposes.

All ponds, regardless of origin are fed by the watertable and surface run-off. The watertable is the upper zone of the limit of saturation. Generally following the contour of the land, the level of the watertable, thus the pond, depends upon the amount of precipitation falling in the area at the time.

'Wetlands'

In your travels, how many times have you looked off the side of a road at a poorly drained area which appears to always have standing water in it laced with different types of vegetation? In essence what you have been looking at is probably a type of a wetlands. Wetlands are broad shallow bodies of water which develop in low lying areas as a result of poor drainage conditions. Depending upon the climate, three very distinguishable types can be identified according to the natural vegetation which continues to thrive in such adverse conditions. Swamps are noted for their many trees basically the bald cyprus and the prop rooted mangrove. Marshes are responsible for the development of specific types of grasses such as cord and triple edged saw grass. The bog is an area noted for the production of sphagnum moss and cranberries. The spahgnum moss is used as peat moss.

In recent years, we have begun to notice the worth of these special water features not only as a source of freshwater, but also as a vital link in the delicate balance of natures ecosystems. In the following passage, we are going to examine two particular wetlands explaining their worth in natures overall scheme of life.

The saltmarsh is a low-lying area of sand and mud located along certain coastlines

where rivers empty into seas or oceans. Within the delta region, a specific ecosystem develops as a result of the mixing of fresh and saltwater. As high tide twice daily inundates (forcefully enter) the delta, the result is a brackish water in which only a few specialized species of sea creatures can exist. Those which have adapted, however, used the lush cord grass as a haven to protect themselves in many cases from predators.

As the tide receeds twice daily as well, some of the creatures are left "high and dry" making a tasty meal for some of the scavengers living in the marsh region. The preditor-prey relation in natures scheme of living ecosystems keeps the balance in check.

Trying to predict the future relevance of an area has always been one of man's many shortcomings. While on the surface, this mosquito infested low land probably appears to be a menace to mankind. It's draing to make room for population settlements doesn't seem like much of a loss. Thanks to ecologists, however, we are finally beginning to understand how these ecosystems work and directly involve all of us. The saltmarsh is and will continue to be an important source of food in the future. Presently, we are obtaining such seafood delicacies as shrimp, crabs, oysters, scallops, tuna, sea bass and flounder. As our interest in these protein rich seafoods continues, the preservation of the saltmarsh becomes more important. Our problem is tied to our ever increasing need to expand our territories for one reason or another. For our own sake, we need to change our priorities.

Our second region of interest is the Everglades of southern Florida. Here we have an example of both a freshwater marsh and a coastal swamp. The Everglades owes its existance to a very large, yet very shallow lake located in south central Florida. Lake Okeechobee has approximately 700 square miles of surface area with a 96 mile coastline. What makes this body of water so unusual is it's depth, only 15 feet at the maximum. Needless to say, when the rainy season hits this region of Florida, this particular reservoir is incapable of holding all of the precipitation which eventually ends up there. Consequently, the overland flow takes the water south

allthe way to the sea. Under normal conditions, the Everglades produces some of the most exotic kinds of wildlife found anywher in the United States.

What has happened in recent years in southern Florida is an excellant example of man's encroachment into a wildlife area attempting to alter it to suit his purposes. With the popularity of the Florida climate, land developers began gaining control of specific areas for the purpose of building housing developments. In order to accomplish this feat, the marsh area of the Everglades, south of Lake Okeechobee had to be drained. Canals were dug emptying the water either into the Atlantic or the Gulf of Mexico. As the land literally began to dry up, housing developments began to spring up. In other words, the natural inhabitants of the marsh were displaced. The entire food chain in some areas collapsed thanks to mans presence.

Thanks to our Federal government, a portion of this once spectacular wetland has now been preserved. Here we have a section of true tropical rainforest vegetation located in isolated clusters along the coast. Refered to as hammocks, this is the only section in the continental United States where this particular type of vegetation evolves. Technically known as a Mangrove Swamp forest, the propped roots of these trees offer an ideal habitat for certain creatures of the Everglades.

PROBLEMS OF WATER CONSUMPTION

Now that we have reached a basic understanding of freshwater and it's importance, let's examine some of the more subtle problems not quite as evident, but still of major significance. While the contamination of surface waters has well been documented and publicized, the pollution and exploitation of groundwater needs to be brought to the attention of the general public as well. Once again, let's turn our attention to those areas of the earth where man's encroachment has led to an excessive use of groundwater.

The Gulf States of the United States where never designed to handle the number of people which have migrated there. As developments are built, water must be supplied to meet the demands of the evergrowing population. The pride many people take in their investments is shown in the care they display for their lawns and gardens. On the surface, this may not seem like a major concern, but what you have to realize is that in many areas city water is very expensive. To alleviate this problem, residential owners may simply tap into the groundwater supply of the area to aquire the neccessary amounts of water for their properties. Being the soil is extremely porous in some instances, much water is lost through deep infiltration. This means more water is needed for simple maintenance. If the city itself also obtains water from local groundwater reservoirs, a rapid depletion of the areas groundwater is inevitable. As the supply dwindles, the ground directly above the watertable may collapse creating what is known as a cone of depression. Newspapers call these areas man-made sinkholes. The sad part about this exploitation is that at times, entire homes, swimming pools and cars have ended up in these depressions eventually becoming submerged as the hole fill up with water. Remembering that water follows the path of least resistance, the surrounding watertable is simply replenishing the depressed area. Too many problems of this nature will lead to a widespread disaster in the preservation of these natural environments.

Along the same line, as groundwater is excessively used along the coastal regions, the watertable of freshwater is sometimes lowered below that of sea level. When this happens, saltwater seeps inland contaminating wells and even damaging or killing the area vegetation if it gets close enough to the surface. This saltwater intrusion along with the cones of depression appear to be only in their infant stages. Unless legislation is enacted and thoroughly enforced, those sources of freshwater which are vital to the gulf regions will remain in serious jeapordy.

In conclusion, the more we know about freshwater and all aspects pertaining to it's relevance, the more of an obligation we have in passing this knowledge down to future generations. Remember, only 1% of the total amount of water which is found on the earth is in the form of freshwater available for our use.

Questions for Assistance

Introduction-The Global Moisture System

1. Of the total volume of water found on the Earth today:
   a. How much is found in the world's oceans?
   b. How much has been temporarily removed from the hydrologic cycle and is presently being stored in the form of glacial ice?
   c. How much is available for human consumption?
   ** State answers in the form of a percent.

2. Explain the process and formation of freshwater.

3. List the 3 properties of water.

4. List and describe the process of change in the 3 states of water.

5. What causes water to change it's form or state?

6. The hydrologic cycle progresses through 4 phases or stages as water is moved from the oceans to the land, and finaly back to the oceans. List those 4 phases.

7. During it's first phase, where do we find the process of evaporation taking place?

8. The largest single contributor of moisture to the atmosphere over land is called _____.

9. By combining evaporation from vegetation, transpiration, and from the soil, the process of _____ takes place.

10. The act of a plant actually releasing water is called _____.

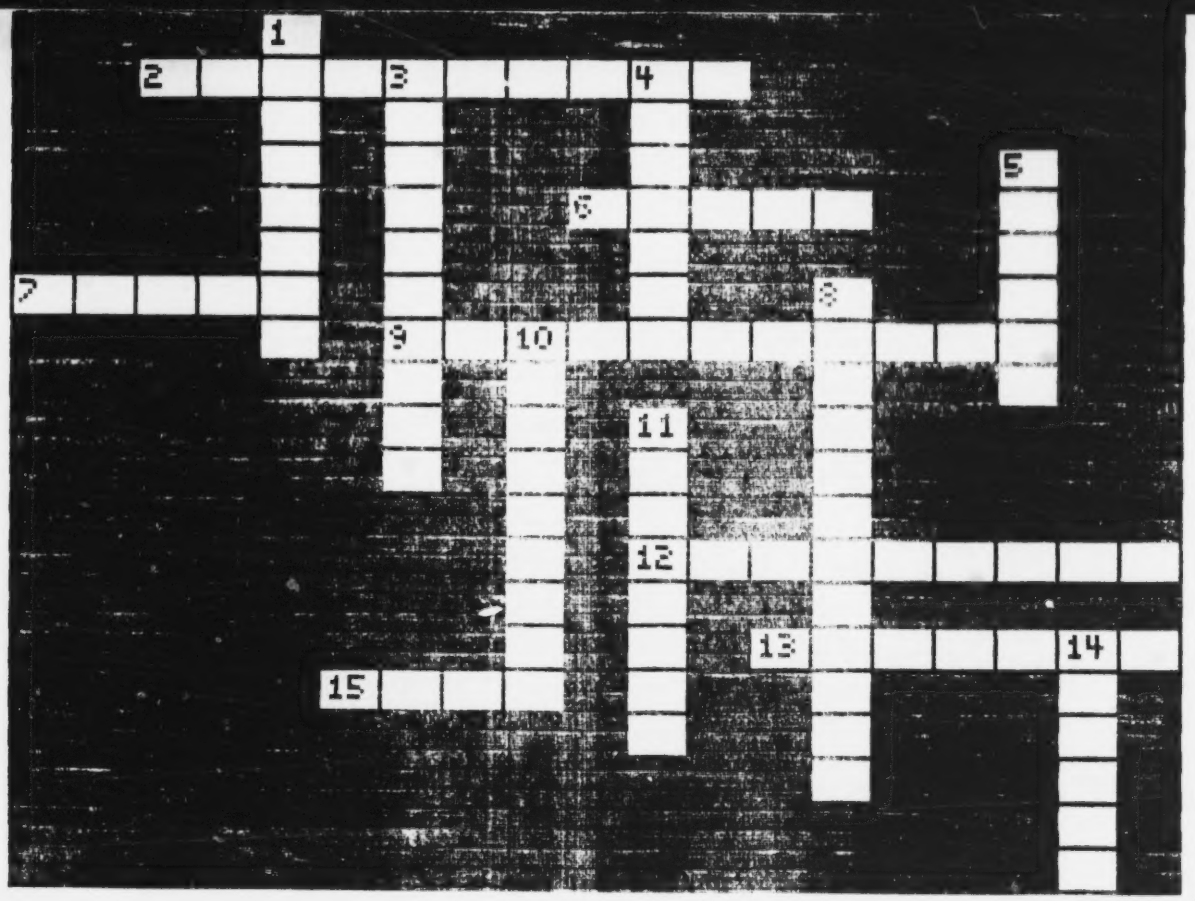
11. During the second phase of the hydrologic cycle, moisture in the form of a gas _____ to that of a liquid thus forming clouds.

12. Once clouds reach teir saturation point, _____ occurs and the third phase of the hydrologic cycle begins.

13. Once water falls from the atmosphere in the form of precipitation and actually enters the ground, the process of _____ commenses, thus beginning the final phase of the hydrologic cycle.

14. Water which is not evaporated, nor runs off into the fresh surface waters, but instead is infiltrated into the ground becomes known as _____.

15. Once water enters the ground, list and describe the 7 areas in which it is transported.



KARST AND GEOTHERMAL FEATURES

ACROSS:

2. steam heat from the earth
6. molten rock material located inside the earth
7. any limestone area where sinkholes are numerous and small streams are nonexistant
9. any non-porous substance which will neither hold water nor allow it to flow through
12. an impermeable rock layer
13. an aquiclude sitting on top of an aquifer holding in the heated water of the earth
15. a hollow or passage cut beneath the surface of the earth which is cut by water

DOWN:

1. the volume of open space in rock and soil
3. pools of hot water on the surface of the earth coming up through fumaroles
4. a permeable rock layer
5. an intermittent hot springs or fountain from which hot water or steam is issued
8. a weak acid produced when water is mixed with calcium carbonate
10. any porous substance which holds water and allows it to flow through it
11. a crack which develops in the caprock resulting from a pressure build up from water
14. a large cave

ANSWER KEY

Across:

2. GEOTHERMAL
6. MAGMA
7. KARST
9. IMPERMEABLE
12. AQUICLUDE
13. CAPROCK
15. CAVE

Down:

1. POROSITY
3. HOTSPRINGS
4. AQUAFER
5. GEYSER
8. CARBONICACID
10. PERMEABLE
11. FUMAROLE
14. CAVERN

Questions for Assistance

Fresh Surface Waters-Problems of Water Consumption

1. Distinguish between "transportation" and "deposition".

2. List and describe the 4 stages of water erosion.

3. List 5 sources or orgins of rivers.

4. List the 7 uses of the freshwater rivers supply.

5. Matching

_____a.	headwaters	1. deposits of silt and sediment located at the mouth of a river.
_____b.	levee	2. a natural floodwall.
_____c.	mainstream	3. any stream which flows into another stream thus contributing water to it.
_____d.	yazoo stream	4. the point of origin of all rivers.
_____e.	tributary	5. when a natural levee blocks the entrance of a tributary from entering the mainstream, the tributary follows the levee until an opening occurs, at which time it can enter.
_____f.	confluence	6. that part of the river which empties into a larger body of water.
_____g.	mouth	7. branches of the mainstream located in a delta.
_____h.	distributary	8. the main flow of water into which tributaries flow.
_____i.	delta	9. that point where two rivers converge.

6. Rivers go through 5 various stages in the history of their development. List and describe each phase beginning with the initial stage and terminating with base level.

7. What is a pond?

8. List and describe 6 different types of ponds.

9. Describe each of the following:
   a. swamp
   b. bog
   c. marsh
   d. saltmarsh
   e. brackish water

10. Of what possible future significance is the saltmarsh?

11. How were the Florida Everglades created?

12. How has man's encroachment into southern Florida damaged the delicate ecosystem of the Everglades?

13. What are hammocks?

14. Using the concepts of a "cone of depression" and "saltwater intrusion", discuss the problems Florida is presently having concerning water consumption.

LIVING IN THE BUBBLE : AN INTRODUCTION TO WORLD POPULATION

Living in the "bubble" of an industrialized nation has the tendency to distort the views many people have of problems which exist in the outside world. Many of these views are formulated by the way media services cover certain events and the way those events are portrayed to the viewing and listening audience. How accurate this coverage is in many instances is questionable. Because of this, the average person living in a "high-tech" society may be totally oblivious or perhaps partially incapable of fully understanding what the ultimate world problem really is. This is quite unfortunate due to the fact that many of the underdeveloped nations of the world already recognize what this problem is and are either incapable of unwilling to do anything about it. The problem I am refering to is the spectre of overpopulation. No other single emergency can compare to this when the overall picture is observed. When one objectively looks at the environmental, political, economic, and religious problems beseiging the world communities today, most, if not all, can trace their roots to the overcrowded conditions of these or neighboring nations. The demands put upon the physical environment of these regions are simply overwhelming and these demands cannot be met.

We in the "bubble" do not see this. Our life, no matter how physically or emotionally draining, does not remotely compare. Maintaining or surpassing our present day standard of living takes precedence over all other factors. While it is true that we as "westerners" travel extensively, most places we visit meet or surpass the creature comforts we are accustom to. Not many of us really want to see how the less fortunate live. Not many of us are interested in the problems which have engulfed these societies. What we cannot seem to visualize is that these very same problems are slowly but surely surrounding and penetrating our "bubble" and will be affecting our society much sooner than perhaps we are willing to realize. Being prepared to deal with these problems which are associated with overpopulation is the key to the future. Let's explore this concept and see what conclusions can be drawn from our findings.

PATTERNS OF POPULATION GROWTH

Demographers, scientists who study people in relation to their number, have estimated through written record that the approximate population of the earth during the 1st century A.D. was 250,000,000.[9] Comparing that statistic with the availability of natural resources and productive living sites, overpopulation and exploitation was not a real factor. What was and still is, is the potential and inevitable doubling of human population. If allowed to continue, this very dangerous scenario will be played out to its fullest as time progresses. A chart showing the chronology of these doubling times will explain this.[10]

Date	Estimated world population	Doubling Time
8000 B.C.	5 million	
1 A.D.	250 million	
1650 A.D.	500 million	1650 years
1850 A.D.	1 billion	200 years
1930 A.D.	2 billion	80 years
1975 A.D.	4 billion	45 years
2000 A.D.	7 billion	

Our attempts towards the understanding and ultimate solving of this problem have been rather futile. Once again, think back to our "bubble" viewpoints about other nations and their problems. After all, they are not presently affecting us so why be concerned?

References have been made and the problem of an overcrowded earth has historically been addressed on a small scale dating back to 1798 when Thomas Malthus wrote his treatise dealing directly with human population growth and the affect it will have on the production and availability of food. Malthus was an English Squire who had the responsibility of overseeing the production of food on his own land and the ultimate dispersal of it. Being quite a statistician, he soon came came to the realization that the pattern of human population growth in the small area he lived was beginning to take its toll on the amount of food which could be produced. The Malthusian Theory brings into focus his ideas concerning this. The concepts of arithmetic and geometric progression were used for the first time in reference to population growth. Stated simply,

when something progresses arithmetically, the progression is a normal arithmetic sequence, 1,2,3,4,5,6.....etc. However, the sequence of a geometric progression looks like this, 2,4,8,16,32,64.....etc. As you can see the geometric progression doubles itself, whereas, the arithmatic does not. Malthus used this analogy to compare human population growth to food production. Disturbingly, what he is telling us is that our population will eventually surpass what food is available and famine will be the next logical sequence in this pattern.[11]

Aside from famine, Malthus also stated that the only other ways to curb this tremendous growth was (1) naturally through the widespread disaster of pestilence or disease or (2) through the man-made events of warfare. What he was unable to forsee was the great strives in technology which has since been achieved. This, however, does nothing but put off the inevitable.[12]

More recently, Dr. Paul Erlich has written a book titled the Population Bomb in which he takes the Malthus premise and expounds upon it using scientific data to back up his writings. Still, our "bubble" society looks but does not see.

POPULATION DENSITY

Population density refers to the number of people existing within a given area. This area is measured either by the square mile or square kilometer. It has been said that approximately 1/2 of the world's population lives on approximately 1/20 of the land which is available. On paper, these areas of dense population have a population in excess of 250 people per square mile when in reality the number is pushing 2,000 to 3,000 if not more. There are four recognizable areas in the world fitting this description:

East Asia- China, Japan, North Korea, South Korea etc.
South Asia- India, Bangladesh, Pakistan etc.
Western Europe- Great Britain, France Spain, etc.
East Central North America- Richmond, Virginia to Boston, Massachusetts

"Reasons for areas of dense population"

Certain reasons prevail as to why these choice sites are so crowdwd. The availability of water is one of the most important factors. Most of the Standard Metropolitan

Statistical Areas (SMSA) of the world are located either on the banks of rivers or very close to other sources of freshwater. The following list of the 5 most densely populated SMSA regions of the earth will clarify this somewhat:

Mexico City, Mexico	population in excess of 18,000,000	built on a lake bed
New York, New York	population in excess of 17,000,000	on the Hudson River
Los Angeles, Cal.	population in excess of 12,000,000	on the Pacific Coast
Tokyo, Japan	population in excess of 11,000,000	on the Pacific Coast
Shanghai, China	population in excess of 10,000,000	on the Yangtze River

With the exception of Mexico City, the proximity of these cities gives them access to the use of the oceans for the importation and exportation of goods and services. Their economy thus has an additional boost.

Latitude is also an important feature in the desirability of living sites. The major SMSA regions are all located in latitudes where the climate is condusive to reasonable comfort. Some climates are less desirable requiring more energy output to artificially alter temperatures to meet the desires of our creatue comforts. The mass influx of human population in some regions has forced the development of these less desirable areas.

Choice agricultural sites is next on the list. Certain areas of the earth have soil which is ideal for the production of agricultural products. Theses areas are rich in the base minerals of nitrogen, phosphorous, and potassium, all of which are neccessary for plant growth. Naturally, more people can be provided for on sites which are available.

Lastly, the accessability to travel routes and what types of land formations are very important. Most cities of any size are located on plains. These lower elevated lands (0-300 feet in relief) offer easier transportation routes and room to expand if neccessary. Summing these qualities up you can see why most of the world's population is located here.

"Reasons for Sparse Population"

On the other end of the spectrum are the areas of sparse population. Here we find environmental conditions which can only support fewer than 25 people per square mile. Worse yet is the frontier. These are inhabited by fewer than 2 people per square mile.

Oddly enough, vast majorities of the earth's continents do indeed exhibit many such areas. Seven are very noticable:

The Amazon Basin of South America
The Sahara Desert- Arabian Peninsula of North Africa and the Middle East
The Namib and Kalahari Deserts of Sub- Saharan Africa
The Gobi Desert of Inner Asia
The Inner Deserts of Australia
The Taiga Regions of North America and the Soviet Union
Antarctica

To fully understand why such regions remain sparsely populated, one must turn to the physical environment. Latitude, once again, is the key factor. Places located between 60-90 degrees north and south of the equator are termed the high latitudes. Here we have areas which experience very long winters in actuality thus very short growing seasons. A growing season is the length of time in between the last killing frost of spring and the first killing frost of fall. In general, as one travels closer to the poles, conditions worsen.

Latitude and relative position on a landmass in conjunction with pressure cells and prevailing or seasonal winds largely determine climatic habitat. Therefore, wide varieties of climatic environments are available to man for settlement. This availablity leaves the habitat open to man's inovations in his adjustments to the hospitable or inhospitable characteristics of the region.

Areas which have deficiencies in the soil restrict large scale population settlements. Soils lacking in the base minerals greatly restrict large agricultural endeavors. These minerals are vital in the production of food as well as all plant life.

Land formations also influence human population settlement. Restricted living quarters exist where the terrain is either too mountainous or too hilly.

Finally, we can examine those areas which are located far from the sources of fresh-water. Aside from the obvious reasons of sustaining life, water resources offer us hydroelectricity, irrigation, transportation, industry, scenic and recreational excursions and waste disposal. All are significant for the large scale settlement of people.

STATISTICAL APPROACHES IN THE CHARTING OF POPULATION GROWTH

Demographers chart the patterned growth of population through a variety of different approaches. These quantitative changes follow either a positive or negative cycle depending upon the region and what conditions those people are subjected too. In order to understand these statistics, one must first be able to comprehend the measuring devises used to chart them.

The birth rate of a nation allows one to observe the potential growth feasibly attainable by that country. To a group of 1000 people, the birth rate is the number of children born to that group during the course of one year. When coupled with the death rate, the natural increase can be calculated. The death rate, simply stated, refers to the number of deaths which occur to that same group of 1000 people during the course of the same year. Once the birth and death rates have been calculated, the growth rate is realized by finding the difference between the two.

For the most part, almost all growth rates around the world are positive. A positive growth rate is achieved by having more births than deaths. This positive growth rate is what the under and undeveloped nations of the world must deal with if they have any hopes of surviving with a quality of life which is condusive to the mean standard.

In a very few instances, however, there are some nations actually registering a negative growth rate. This means there are more deaths than births within that nation. These nations are striving to gain control of their population in order to provide a decent standard of living for all.

Idealistically, the only realistic goal which the earth can set for itself in the near future is what is known as Zero Population Growth (ZPG). ZPG is attained when the birth rate and the death rate are equal. If parents would limit their families to 2 children, in essence replacing themselves only, ZPG could be reached. The problem, however, is turning around what is called momentum.[13] Imagine what it is like to stop

an automobile going down a steep hill at a high rate of speed. It cannot be done all at once simply because the car has too much momentum going for it. This analogy is also true with the growth of population. If you recall, Malthus brought to our attention the fact that human population growth is increasing geometrically. This doubling effect is what we are contending with today and that is going to take some time to control.

Another clue pertaining to the growth of a nation lies within it's fertility rate. Socio-economic trends can be plotted by keeping close tabs on this statistic. By comparing the number of children under the age of 3 within a given population to the number of women between the ages of 15-45, the demographer can attain a very firm foundation from which population projections can be made. The significance of this age group is related to it's ability to bear children. Being the most productive child bearing years, nations which show large numbers in this catagory have the potential of a rapidly expanding population. Add to that the fact that with more children the average age of the nation decreases, the possibility of a higher birth rate can once again be seen on the horizon. This vicious cycle is how momentum gets started and continues to grow. Combined with the relative importance of education, the factor of the literacy rate now becomes of vital concern. Designed as a percentage, the literacy rate makes reference to that segment of society over the age of 15 who can read and write and can be instrumental in predicting whether the growth rate will be positive or negative. In general, those nations which have low literacy rates are overpopulated and must contend with all of those problems associated with that situation.

Along the same lines, one can examine the infant mortality rate of a nation and make inferences relating to the health care, literacy rate, growth rate, birth rate, ...etc. Specifically, to a group of 1000 live births, the infant mortality rate is the number of children within that group which die befor the age of 1. While specific causes of death cannot be judged from this statistic, higher infant mortality rates seem to plague nations which are underdeveloped.

The concept of health care is most easily examined by an analysis of life expectancy. This statistic deals with the average life span (in years) of both men and women. With the availability of modern medical technology, people are living longer which can lead to an explosive growth rate. The problems commonly associated with overpopulation have a tendency to appear in nations statistically displaying shorter life spans. It should be emphasized, however, that because of the high infant mortality rate found in many of the third world nations, the average life spans are unjustly low.

As the pattern continues to reveal itself, one can actively observe the nations economy and make some judgements. The gross national product of a nation is based on how much capital is being brought into that country during the course of one year. Poorer nations tend to have single resource economies basing their whole existance on either one mineral product or one cash crop which is in demand at the time. If the world market changes and their major export item is no longer needed or important, their economy suffers. This also causes the per capita gross national product (PCGNP) to fluctuate as well. The PCGNP is the average income attributed to each individual within the nation. It is attained by dividing the GNP by the countries population. Consequently, those countries with single resource economies and large populations tend to have lower PCGNP's. As you can see, momentum continues to have an affect upon these societies.

Narrowing the spectrum to the SMSA's of a nation, one can observe the urban growth rate attributed to that nation and possibly draw some conclusions about the population growth there. The urban growth rate is calculated the same as any other growth rate but gives one a look at the nations mobility in relation to rural and urban communities. This growth rate deals with the cities and their growth either due to technology or the hope for it. Cities develop when a populace needs diversity. This diversity is based upon the manufacturing of products which are actively sought in the open market. Cities are, however, completely dependent on the basic resources provided by rural areas. Including food, all of these resources must be imported before any finished product can be exported.

Being that cities offer hope for a brighter future and better jobs, many people move there seeking these opportunities. This movement towards the cities and their surrounding areas develope in many instances into what is called a megalopolis. Coined by the French geographer Jean Gottman, a megalopolis is an area which becomes very densely populated and spread out over a large region. The urban sprawl generally encompasses several cities where the visible boundary between each is not clearly defined. A prime example is clearly shown in a photograph taken at night from a satallite over the east coast of the United States. The area from Richmond, Virginia to Boston Massachussets appears to be one continuous band of light.

All too often, people who re-locate to the urban centers lack the basic skills and training neccessary for securing employment. Pockets of extreme poverty develope on the outskirts of the downtown business district. As the cities continue to grow, so do these pocket areas. How to stop this by-product of momentum could make a difference between the success and failure of a nation.

PROBLEMS ASSOCIATED WITH OVERPOPULATION [14]

While it is true that many of the developed nations of the world which are experiencing crowded conditions are still able to maintain a descent standard of living, they can learn by observing the less fortunate ones who have major problems. One of the most obvious difficulties is displayed by a countries inability to feed it's own people. Often accompanying these excessive numbers within a country is the lack of a proper diet and starvation. Proper diets consist of those which provide enough protein and vitamins neccessary to maintain a healthy body. Protein, those building blocks consisting of 20 amino acids found in certain foods, is an absolute essential in one's diet. Protein deficiency is called malnutrition or malnourishment. This lack of protein can lead to severe problems. For example, an expectant mother needs a proper diet to insure the proper development of her unborn child. In extreme situations, failure to receive such a diet can damage the baby both mentally and physically. A very severe form of protein deficiency which shows up in new born babies is called kwashiorkor. Here, the damage is irreprable.

Caloric intake, along with the proper amounts of protein, is also essential to good health. The Food and Agricultural Organization (FAO) states that the minimum daily caloric intake one should have is 2300. If one is unable to attain this amount and proper nutrients are not suplimented by other means, undernourishment will develope over a period of time. Undernourishment does not neccessarily include a protein deficiency but in most cases does. The overwhelming result of this deficiency is called Marasmus. This can affect anyone.

Once malnutrition or undernourishment takes hold, the bodies resistance to illness soon begins to break down. These two facets working together are almost always fatal. Widespread death which occurs over a short period of time as a result of starvation or some other cause is termed megadeath. Unfortunately, this is one of natures ways of correcting overpopulation.

Another problem which accompanies an overpopulated region has to do with housing. Providing basic shelter which is conducive to the surroundings isn't always possible. Sometimes there are not enough natural resources within the area to support the numbers. As a result, nations may have to resort to importing what materials are neccessary in order to bring the housing up to an acceptable norm. Not all countries can afford to do this. Many of the underdeveloped nations of the world will always be confronted with this. As is evident, the momentum of population growth presents itself again.

Nations plagued with the problems of overpopulation are generally associated with economies which are not diverse enough to help supplement what monies they do get from their major sources of revenue. Once again, single resource economies or those societies in which the major source of income is based on a cash crop or one mineral product simply cannot employ very many people. Relying on the consistency of the world market and their need for that one product presents a great deal of uncertainty in that economy. What industries they do have are of the "home" variety and not large enough to mass produce any quantity let alone the quality which attracts business. The unskilled and unemployed become quite abundant.

Large metropolitan areas in which industry is a major source of revenue have a

tendency to be the largest polluters. In most cases, the environment is not equipped to handle such an influx of people or industry. Serious issues dealing with the excessive use and depletion of existing energy resources, pollution, and waste disposal must be addressed before the ecosystems of these areas are completely destroyed. Nature has delicately balanced ecosystems to consist of both the physical and biological aspects of an area and has made life, thus, conducive to that balance. People, moreso than animals, are harsher on the environment for the simple fact they have no natural predator to control their numbers. With no natural population control, man has been left to run rampant over his habitats with absolutely no regard to the consequences. Being that we have had to implement measures to conserve our non-renewable resources is an indication of our inability to project ahead. One can only ask, "has the lesson been learned too late?"

Becoming accustomed to certain natural resources and not giving their use a second thought has become second nature to us. Water is a prime example. Of all the water which is found on the earth, 97% is in the oceans. Two percent is wrapped up in the glacial ice of the poles. That leaves 1% in the form of freshwater found in our rivers, lakes, ponds.....etc. When one considers that, our consumption and use of this precious resource should be of the utmost importance. Treatment centers, designed to treat our waste, seem only marginal at best. In many of the densely populated regions of the world, water may not be treated at all and if it is, drinking it is not totally advisable.

Water treatment facilities generally fall into three catagories depending upon the degree of treatment. Primary treatment plants take the used water from cities and channel it through sewers into large collecting basins where the solid waste products are removed. After this, the water is allowed to sit while the suspended solids settle to the bottom at which point it is then released into the surrounding rivers, lakes, or what other reservoir is available where it is carried off. Needless to say,this is not the best method to treat water for its eventual reuse.

Secondary treatment plants carry the cleaning process one step further. After allowing the procedures described in the primary treatment of water to be carried out, chemicals are added to the water killing what bacteria there is in it. The water is then disposed into rivers or lakes.

If a community is willing or capable of paying enough, they can incorporate a tertiary treatment plant. Tertiary treatment carries the treatment process through yet one more phase. After the secondary phase has been completed, the water is then passed through charcoal filters which will possibly purify it. This comes very close to putting the water back to its natural state and, of course, is the most ideal method available to us today.

Ironically enough, in the most densely populated regions of the underdeveloped regions little, if any, water treatment can even be considered. Too many other pressing problems exist and must be dealt with first. It seems very difficult for people living in the "bubble" of the western nations to comprehend how others can continue to live and have children when the odds of that child living beyond the age of one is, at best, pure chance. As mentioned, these children are more suseptable to diseases and malnutrition, yet, their numbers still increase as is evident by the birth rates being recorded. One does not have to agree with the reasons for or the results of overpopulating our earth, but maybe a better understanding can be reached and questions yet unanswered can now be explored.

BASIC REASONS FOR OVERPOPULATION [15]

Since the beginning of the Twentieth Century, more scientific knowledge has been accumulated than all times previous to that time. One such field of advancement involves medical technology. The prevention and cure of many diseases which were at one time considered fatal are now very much possible. Vaccines for such dreaded diseases as polio, small pox, cholera, tuberculosis, diptheria.....etc. have been developed. What was once natures way of somewhat controlling population growth has now been diverted by man.

The goal of many nations is to completely eliminate some of these diseases. The world wide elimination of small pox has already been achieved. Through such medical organizations as CARE, the International Red Cross and the World Health Organization (WHO), the widespread distribution of vaccines and preventative techniques have saved many lives thus lengthening the life expectancy of many people.

The cultural and religious opposition to birth control has also put a tremendous strain on certain countries around the world. Many nations affected by these beliefs are found in the Latin American realm. Being mostly Roman Catholic, the people basically follow the mandates of Rome which adamantly display opposition to birth control. The governments of these nations, however, realize the pressure and disasterous effects overpopulation has upon their countries are beginning to support measures of birth control.

Let's look specifically at the world's largest metropolitan area, Mexico City. In 1985, Mexico City had a population in excess of 18,000,000. At that city's current growth rate, the projected population by the year 1988 will be in excess of 20,000,000. What this has done to the city must really ~~be~~ observed in the faces of its residents. By living in our "bubble", we cannot remotely relate to the problems shared by the residents of this metropolitan community. Momentum still prevails.

As is quite obvious, most crowded nations lack a certain amount of education about family planning. Tradition, as we are going to find, is perhaps the hardest concept to change. To ease the socio-economic problems which simply overwhelm many people, tradition holds that families should either live together or in close proximity to one another. In this respect, much of the burden which plagues these people can be distributed among the members of the family thus taking the pressure o ff of a few. What they don't seem to be able to understand is that much of their socio-economic dispaire is related to their numbers. In a country where subsistence level farming is a way of life, for the most part there is not enough food to provide proper diets for the family members. Because of this, the trend today is for some of these members to leave and seek employment elsewhere. By doing this, money can be sent back to the village to supplement their income and diet.

Small "home" style industries are also developed in hopes of bringing money into the home. At best, these supplemental incomes are not enough to show significant benefits, but the feeling of hope does exist that one day there will be jobs enough for those who leave or a market for the products made and this will make a difference.

Families which find themselves in this predicament tend to exhibit many of these problems associated with overpopulation. The infant mortality rate is generally higher due to the inavailability of proper medical facilities and the improper diet the expectant mother experiences during pregnancy. Statistically it can be proven that the younger a women is when she has her first child, the less education she will aquire and the more children she will have.

While making reference to women, let's examine the rôle women are expected to follow in certain areas of the world. In the under and undeveloped nations, women traditionally are expected to fulfill the role of wife and homemaker. Their largest contribution to these sccieties is one of having children and keeping house. The education of women is not looked upon as an advantage. Men feel superior and in essence treat them as second class citizens. Not really knowing any other role, women very seldom question this philosophy and simply accept their existence.

Following this premise, it stands to reason that this lack of respect women have in these regions would lead to a very high rate of un-wed mothers. It is not uncommon to see women with 3 or 4 children sleeping in the streets and begging for food with their children.

The economic base for most of the countries of the world still lies in agriculture. While many of the developed nations of the world utilize modern farm implimentation and technology, a large number of the developing countries are still struggling with primitive methods leading to subsistence levels. For this reason, large families are looked upon with great respect and pride because this enables the work on the farm to be distributed making the actual physical labor easier. A formal education is not neccessary because children need only learn what is

neccessary to live on the farm. Not learning those responsibilities could be very detrimental to the entire family unit being that every job is instrumental to the well being of the whole.

One cannot assume that in countries other than the United States and the developed nations of the world that care for the elderly is a social program built into the socio-economic structure of the nation. In most of the underprivileged nations this problem is not even addressed. The elderly must simply care for themselves. Taking this into account, large families consisting of many children are looked upon as the solution to this problem and are held in great esteem. With many children to look after them, parents know their final days will at least be spent with loved ones.

While this may not cover the entire gambit of reasons behind overpopulation, perhaps some thought has been stimulated and a basic understanding further developed.

GLOBAL ATTEMPTS

Before one can derive any sort of basic conclusions pertaining to problems associated with overpopulation, the simple question as to whether or not food is a basic human right or simply a commodity which is to be bought and sold in the open market to the highest bidder must first be answered. This extremely emotional question must be dealt with on a world wide basis. Not until recently have significant attempts been made and short term successes been recorded.

Dr. Norman Borlaug, a plant pathologist, won the Nobel Peace Prize in October of 1970 for his work in the development of hybrid seeds which would increase the crop yield per acre of certain grain products. Coined the "Green Revolution", this new era which was developed by Borlaug meant hope was at least on the horizon whereas before, the overall picture was really quite grim. By developing seeds which were a genetic mixture of other strains of the same crop, a single plant could be produced which exhibited the traits condusive to growing the best plant for the region. What that meant to the producer was that more food could be aquired per acre.

Dr. Borlaug, in reality, had temporarily diminished the real spectre of world famine.

Beginning with wheat, Borlaug first tested his hybrid seeds in Mexico. The results were fantastic. Crop yields tripled the first year. While this was not the ultimate panacea to the problem, mankind at least had bought some more time. The use of these hybrids is just beginning. To get the maximum yield from the seeds however, the farmers must have access to modern farm essentials such as fertilizers to replenish minerals, pesticides to control insects, herbicides to control weeds, and irrigation if neccessary. Farming today is not quite as simple as it was years ago basically because of the demand for wide scale production of what ever is being produced. These newer techniques in the production of food will work if the farmers are educated and the materials neccessary for the growing of these crops are made available.

Agriculture is not simply limited to the land we live on. One of the last untapped resources left on our earth is the oceans. Aquiculture, the farming of the sea, is such a branch. Tremendous quantities of fish can and are being obtained from the sea and thus supply not only food for the masses, but excellant sources of protein to those nations sadly lacking in this essential. In addition to fish, kelp and other vegetation from the sea can be used. The problem, as always, is going to be the wise management of these resources. The fishing limitations each nation sets in accordance with the United Nations develope guidelines to proper management. Fish and other sea products will be an ever increasing and important part of our diets in the future.

In areas where space is of the utmost importance, a type of agriculture called hydroponic farming is being used which has the potential of producing as much if not more than conventional farms. Crops are designed to be grown in a greenhouse where water mixed with high concentrates of fertilizers are introduced to the seeds in a very confined area. This constant flow of fertilizers creates an environment which is condusive to attaining mass quantities of produce. The controlled conditions of hydroponic farming gives farmers a year round growing season which not only ben-

efits him, but also those who will obtain the food he can grow.

Slowly, but nevertheless very methodically, western nations of the world are changing their diets to include more fish, chicken and poultry items as their major source of protein. The red meats are being replaced. The production of cattle requires alot of care as well as land. Just before cattle are sent to the market for slaughter, farmers fatten them on grain, basically corn. On the average it takes 8 pounds of grain to produce 1 pound of beef.[17] Combined with the land which is neccessary to graze the cattle, this becomes a very expensive operation. Obviously it takes a considerable amount of money to grain feed cattle, but it also takes a considerable amount of grain, grain which instead could be used to feed people.

Fish and chicken, on the other hand, require much less land and food to ready them for the market. As stated, we are beginning to turn to the oceans for much of the fish products found on the shelves of the market places today.

Chicken can also be raised in confined areas. Some of the large scale chicken houses can hold up to 14,000 chickens at one time. Food and water is brought into these houses on conveyor belts. At the end of a nine week period (the time it takes chickens to reach fryer weight) the chickens are sold, the houses cleaned, and the manure sold as fertilizer. Another batch of chickens is then brought in and the process begins again. There feasibly can be as many as 5 turnovers of chickens in one year in one house alone. Add to that the fact it takes only 2 pounds of grain to produce 1 pound of chicken and you can see the process is much cheaper and takes much less room.[18] The grain saved in this process can be used by people as well.

To those who are observant about happenings within their own community, perhaps it has become evident that the super markets are giving more shelf and refrigerator space to fish and chicken products and less to beef. Fast food restaurants are now including fish, chicken and maybe even turkey entrees along with beef. More attention is also being given to these items in the nicer establishments where you go to dine. Doctors are telling us that red meats are not as healthy for us as once thought. The western diet has historically been one of choice because of the abundance of food, but as you can see, the whole concept of what meat[illegible] at [illegible] in the process of

changing and will continue to do so in the near future. As long as there is a continued growth in the population, more grain is going to be needed for food, and the space once used for animals is going to be needed for people.

CONCLUSIONS

Having explored the varying facets of human population growth, what conclusions can we who live in the "bubble" of the western developed nations formulate? The fact that the present population of the world is slightly over 5 billion and at current trends is projected to reach 7 billion by the year 2000 doesn't paint a very bright future. Problems, both economically and socially which have never presented themselves before, are going to eventually surface. The following worksheet, designed to graph selected statistical data pertaining to population, may be quite helpful. By using comparative analysis techniques, one of three topics can be observed:

1. With the use of current data, nations as well as regions can be compared with one another.

2. By using older data with the current, one can observe how nations compare today with years previous.

3. Continuing with the trends as shown in the second step, one can then project ahead to what possibilities may be in store for the world in the future.

For those of us in the "bubble" who are willing to listen, what has been discussed along with the research needed to complete the worksheet should be quite enlightening.

Questions for Assistance

Introduction-Population Density

1. Explain how people living in the "bubble" of an industrializes nation have a distorted view of problems overpopulation create in the less developed countries of the world.

2. _____ are scientists who study people in relation to their numbers.

3. Explain the basic premise of the Malthusian theory of population growth using arithmetic and geometric progression as an illustration.

4. What solutions did Thomas Malthus see as a means of combating these alarming figures?

5. What is population density?

6. Any area which has more than _____ people per square mile is considered to be an area of dense population.

7. List the 4 areas of dense population of the Earth.

8. What does the acronym SMSA refer too?

9. List the 5 major SMSA's of the world today along with their approximate population.

10. List 4 reasons why these densely populated areas of the world are considered choice living sites as opposed to the less desirable ones.

11. Any area which has less than 2 people per square mile is considered a _____.

12. What factors determine an area to be sparsely populated?

13. List the 7 major areas of the world considered to be sparsely populated.

Questions for Assistance

Statistical Approach es in the Charting of Population Growth-Problems Associated with Overpopulation

1. Matching

_____	birth rate	a. calculated the same as any growth rate, this deals strictly with the growth of the urban areas of the world.
_____	death rate	b. the difference between the birth rate and the death rate.
_____	growth rate	c. to a group of 1000 people, the number of women between the ages of 15 and 45.
_____	positive growth rate	d. stated as a percent, the number of people over the age of 15 who can read and write.
_____	negative growth rate	e. to a group of 1000 people, the number of births registered to that group during the course of one year.
_____	fertility rate	f. attained when the birth rate of a country exceeds the death rate.
_____	infant mortality rate	g. to a group of 1000 live births, the number of babies which die before the age of one.
_____	literacy rate	h. to the same group of people used to calculate the birth rate, the number of people within that group which die during the course of one year.
_____	life expectancy	i. the average number of years men and women can expect to live.
_____	urban growth rate	j. attained when the death rate of a country exceeds the birth rate.

2. What is the difference between the Gross National Product and the Per Capita Gross National Product?

3. What is a megalopolis?

4. What is malnutrition and how does it differ from undernutrition?

5. Distinguish between kwashiorkor and marasmus.

6. List the major problems associated with overpopulation.

7. Being that pollution is one of the major problems associated with overpopulation, the use and treatment of the precious comodity of water is of increasing importance on the world scene. Explain the various methods nations use to treat water in order for people to use it.

Questions for Assistance

Basic Reasons for overpopulation-Global Attempts

1. List and explain 5 basic reason for overpopulation.

2. Discuss the following:
   a. Dr. Norman Borlaug
   b. Green Revolution
   c. aquiculture
   d. hydroponic farming
   e. a protein based diet consisting of basically red meat changing to that of poultry and fish

GRAPHING SELECTED STATISTISTICAL DATA PERTAINING TO POPULATION

STATISTICALLY, GRAPHING POPULATION DATA CAN BEST BE SERVED IF THE WORLD COMMUNITIES ARE DIVIDED INTO CERTAIN REGIONS ACCORDING TO THEIR GEOGRAPHIC PROXIMETY. LISTED BELOW ARE THESE REGIONS:

1. EAST ASIA
2. SOUTHEAST ASIA
3. SOUTH ASIA
4. NORTH AFRICA
5. MIDDLE EAST
6. SUB-SAHARAN AFRICA
7. ANGLO AMERICA (NORTH AMERICA)
8. CENTRAL AMERICA
9. SOUTH AMERICA
10. EUROPE
11. AUSTRALIA AND NEW ZEALAND

** REFER TO THE LIST OF INDIVIDUAL COUNTRIES WHICH MAKE UP EACH REGION

ASSIGN ONE STUDENT GROUP FOR EACH GEOGRAPHIC REGION. STUDENTS ARE TO USE REFERENCE MATERIALS IN THE ACCUMULATION OF THE FOLLOWING DATA:

1. BIRTH RATE (BR)
2. DEATH RATE (DR)
3. GROWTH RATE (GR)
4. INFANT MORTALITY RATE (IMR)
5. LIFE EXPECTANCY (LE)
6. PHONES
7. RADIOS
8. TELEVISIONS
9. NEWSPAPERS
10. PER CAPITA GROSS NATIONAL PRODUCT (PCGNP)
11. HIGHWAYS/RAILROADS
12. POPULATION DENSITY
13. CONTINENTAL POPULATION
14. LITERACY RATE (LR)
15. URBAN POPULATION (UP)

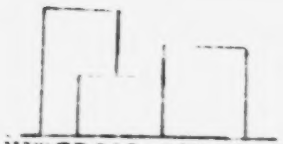
AFTER THE SELECTED DATA FOR EACH REGION HAS BEEN ACCUMULATED, CALCULATIONS SHOULD BE MADE TO DETERMINE THE REGIONAL AVERAGES FOR EACH ITEM OF DATA.

HAVING CALCULATED THE REGIONAL AVERAGES, GRAPHS ARE TO BE DRAWN REPRESENTING THIS DATA. STUDENTS ARE TO USE THE FOLLOWING FORMAT:

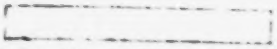
1. VERTICAL OVERLAPPING BAR GRAPHS ARE TO BE DRAWN REPRESENTING BR, DR AND GR.
2. A SINGLE HORIZONTAL BAR GRAPH IS TO BE DRAWN REPRESENTING THE IMR.
3. A DOUBLE HORIZONTAL BAR GRAPH IS TO BE DRAWN REPRESENTING THE LE. THE TOP BAR IS TO REPRESENT THE MANS AVERAGE LE WHILE THE BOTTOM IS TO REPRESENT THE WOMENS.
4. A SINGLE HORIZONTAL BAR GRAPH IS TO BE DRAWN REPRESENTING EACH OF THE FOLLOWING:
   PHONES
   RADIOS
   TELEVISIONS
   NEWSPAPERS
5. A SINGLE VERTICAL BAR GRAPH IS TO BE DRAWN REPRESENTING THE PCGNP
6. A DOUBLE HORIZONTAL BAR GRAPH IS TO BE DRAWN REPRESENTING HIGHWAYS/RAILROADS. THE TOP BAR IS TO REPRESENT HIGHWAYS WHILE THE BOTTOM IS TO REPRESENT RAILROADS.

7. A SINGLE VERTICAL BAR GRAPH IS TO BE DRAWN REPRESENTING:
   POPULATION DENSITY
   CONTINENTAL POPULATION
8. CIRCLE OR PIE GRAPHS ARE TO BE DRAWN REPRESENTING THE IN AND THE UP.

EXAMPLES OF THE REQUIRED GRAPHS

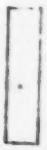


VERTICAL OVERLAPPING BAR GRAPH



SINGLE HORIZONTAL BAR GRAPH

DOUBLE HORIZONTAL BAR GRAPHS



SINGLE VERTICAL BAR GRAPH

CIRCLE OR PIE GRAPH

STUDENT GROUPS ARE TO NOW COMPILE THE COMPLETED REGIONAL GRAPHS AND DRAW A COMPARISON CHART CONSISTING OF ALL OF THE COMPLETED GRAPHS BEING SURE TO LABEL EACH REGION. DRAW EACH GRAPH IN DESCENDING ORDER BEGINNING WITH THE LARGEST OR HIGHEST RANKING REGION.

USING THE COMPARISON CHARTS, STUDENTS ARE TO NOW FORMULATE CONCLUSIONS PERTAINING TO THE FOLLOWING:

1. POPULATION TRENDS
2. HEALTH CARE
3. COMMUNICATIONS
4. ECONOMY
5. TRANSPORTATION LINKAGES
6. HOUSING AND LIVING SPACE
7. EDUCATION

EAST ASIA
CHINA
JAPAN
SOUTH KOREA
NORTH KOREA
TAIWAN

SOUTHEAST ASIA
BURMA
INDONESIA
KAMPUCHIA
LAOS
MALAYSIA
PAPUA NEW GUINEA
PHILIPPINES
SINGAPORE
THAILAND
VIETNAM

SOUTH ASIA
AFGHANISTAN
BANGLADESH
BHUTAN
INDIA
NEPAL
PAKISTAN
SRI LANKA

NORTH AFRICA
ALGERIA
CHAD
EGYPT
LIBYA
MALI
MAURITANIA
MOROCCO
NIGER
SUDAN
TUNISIA

MIDDLE EAST
BAHRAIN
IRAN
IRAQ
ISRAEL
JORDAN
KUWAIT
LEBANON
OMAN
QATAR
SAUDI ARABIA
SYRIA
TURKEY
UNITED ARAB EMERATES
NORTH YEMEN
SOUTH YEMEN

SUB-SAHARAN AFRICA
ANGOLA
BENIN
BOPHUTHATSWANA
BURUNDI
CAMEROON
CENTRAL AFRICA
CISKEI
CONGO
DJIBOUTI
EQUATORIAL GUINEA
ETHIOPIA
GABON
GAMBIA
GHANA
GUINEA
GUINEA-BISSAU
IVORY COAST
KENYA
LESOTHO
LIBERIA
MADAGASCAR
MALAWI
MAURITIUS
MOZAMBIQUE
NAMIBIA
NIGERIA
RWANDA
SAO-TOME/PRINCIPE
SENEGAL
SEYCHELLES
SIERRA LEONE
SOMALIA
SOUTH AFRICA
SWAZILAND
TANZANIA
TOGO
TRANSKEI
UGANDA
UPPER VOLTA (BURKINA FASO)
VENDA
ZAIRE
ZAMBIA
ZIMBABWE

NORTH AMERICA
CANADA
UNITED STATES

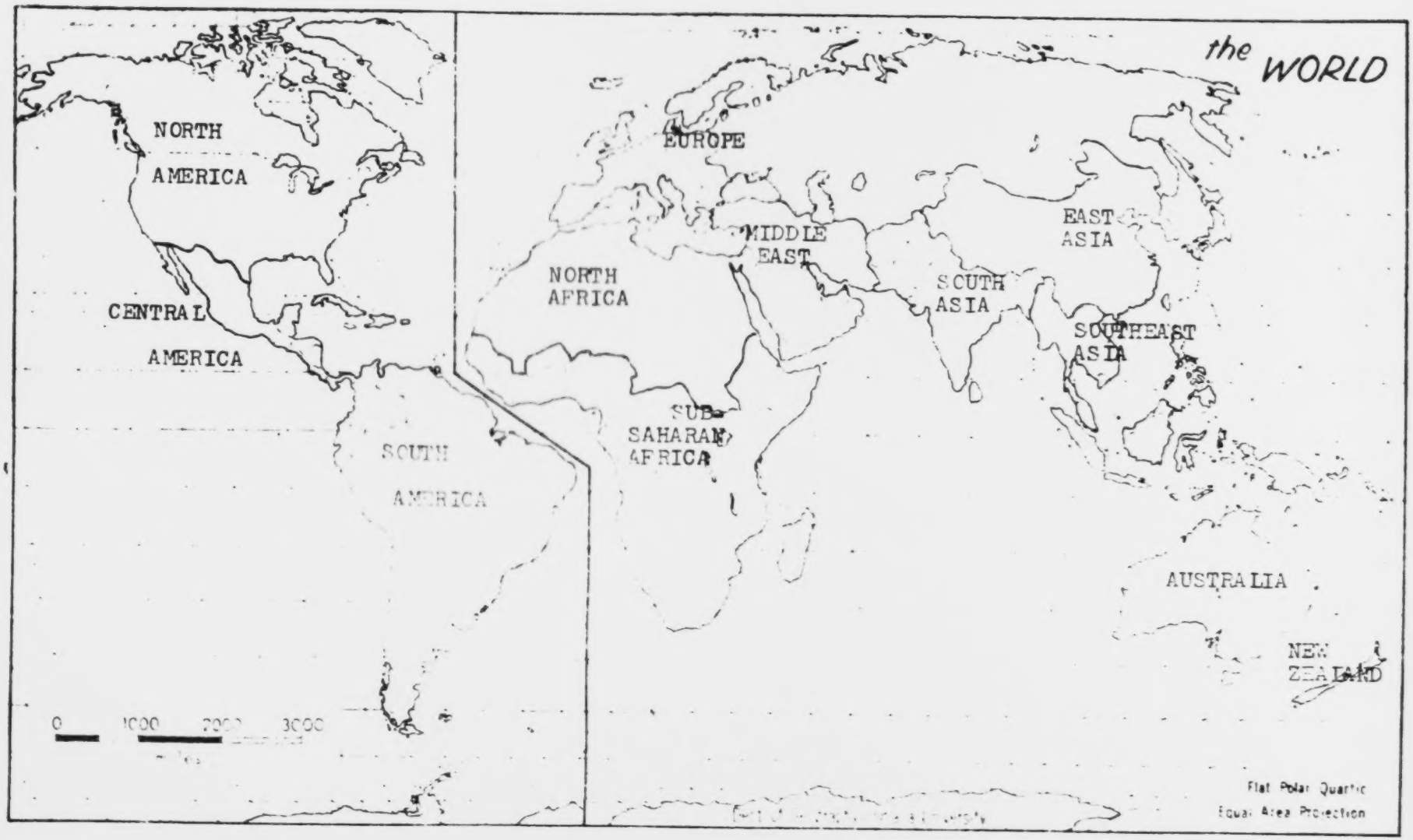
CENTRAL AMERICA
BELIZE
COSTA RICA
EL SALVADOR
GUATEMALA
HONDURAS
MEXICO
NICARAGUA
PANAMA

SOUTH AMERICA
ARGENTINA
BOLIVIA
BRAZIL
CHILE
COLOMBIA
ECUADOR
GUYANA
PARAGUAY
PERU
SURINAME
URAGUAY
VENEZUELA

EUROPE
ALBANIA
ANDORRA
AUSTRIA
BELGIUM
BRITIAN
BULGARIA
CZECHOSLAVAKIA
DENMARK
FINLAND
FRANCE
EAST GERMANY
WEST GERMANY
GREECE
HUNGARY
IRELAND
ITALY
LIECHTENSTEIN
LUXEMBOURG
MONACO
NETHERLANDS
NORWAY
POLAND
PORTUGAL
ROMANIA
SAN MARINO
SOVIET UNION
SPAIN
SWEDEN

EUROPE(CONT)
SWITZERLAND
VATICAN CITY
YUGOSLAVIA

AUSTRALIA
AUSTRALIA
NEW ZEALAND


the WORLD
NORTH AMERICA
CENTRAL AMERICA
SOUTH AMERICA
EUROPE
NORTH AFRICA
MIDDLE EAST
SUB-SAHARAN AFRICA
SOUTH ASIA
EAST ASIA
SOUTHEAST ASIA
AUSTRALIA
NEW ZEALAND
0
1000
2000
3000
Flat Polar Quartic
Equal Area Projection

GLOSSARY

adaptation- the ability of plants and animals to adjust to their environmental surroundings.

air mass- a large mass of air exhibiting homogeneous traits in relation to temperature and humidity when a horizontal cross section is examined.

alluvial fan- (a) deposits of silt and sediment located at the base of coastal mountain systems in essence resembling a small delta. (b) an example of a neutral shoreline.

altitude- height above a given surface.

aphelion- the farthest position the Earth is from the sun in it's revolutionary orbit. This takes place when the Earth is 94.5 million miles from the sun on July 4.

aquaculture- the farming of the sea.

arithmetic progression- a numerical sequence which progresses in a normal pattern: 1,2,3,4,5,.....etc. The way food increases according to Thomas Malthus.

autotrophs- plants which require sunlight to grow.

axis- an imaginary line extending from pole to pole while passing through the center of the Earth, around which the Earth rotates.

badlands- the worst form of water erosion. Usually the result of meltwater from a glacier.

base level- an imaginary inland extension of sea level, or the lowest level a river is capable of eroding down to when that river flows into another river, lake, sea, etc.

base minerals- the mineral of nitrogen, phosphorous, and potassiym which are neccessary for plant growth.

barrier reef- a coral reef which is separated from the mainland by a shallow body of water.

biochore- another name for a biome- a sub-division of the Earth's biocycles.

biocycle- sub- division of the Earth's biosphere. Consists of land, freshwater and saltwater.

biological environment- those parts of one's environment which are organic, living, or having lived. Plants and animals.

biome- sub-division of the Earth's biocycles.

biosphere- those areas of the Earth where life exists.

birth rate- to a group of 1,000 people, the number of babies born to that group during the course of one year.

bog- a wetland in which moss (sphagnum mainly) is the main type of vegetation.

Borlaug, Dr. Norman- responsible for the development of hybrid wheat seeds which began the Green Revolution. Won the Nobel Peace Prize for his efforts in 1970.

brackish- a combination of fresh and saltwater. Found generally in coastal salt-marshes.

calcification- one of the major soil developing processes. Located in the drier climates where the effects of water erosion are not as pronounced. Responsible for some of the world's richest soils.

caldera- the collapsed top of a volcano. i.e. the Kilauea caldera on the big island of Hawaii.

canyon- steep walled valley.

carnivore- animal which eats only meat.

census- a periodic governmental count of the population.

centrifugal force- the tendency for very small objects such as dust and water vapor to be "thrown" off of or "pulled" from the surface of the Earth due to it's rotational velocity.

circle of illumination- zone of separation between daylight and darkness.

circum-Pacific belt- actually the border of the Pacific plate where most of the Earth's volcanic and earthquake activity takes place.

climate- the average weather conditions as observed over a particular place over an extended period of time.

climax community- that community of plant growth found in the final stage of natural succession. That which continues to renew itself.

climax vegetation- the particular dominant plant specie found in the climax community.

compound shoreline- a major classification of shorelines which is composed of 2 or more of the other major groups. (shoreline of submergence, shoreline of emergence, neutral, and faulted shorelines)

condensation- the natural process by which water in the form of a gas is changed directly into that of a liquid as a result of a temperature change.

conduit- the "tube" in a volcano through which magma is channeld to the surface (crater).

cone of depression- due to the rapid delpeation of an areas groundwater, the ground directly above becomes unstable and generally collapses, creating a man-made sinkhole.

confluence- that point where two rivers flow together.

Continental Drift Theory- as 1st proposed by Alfred Wegener, this theory stated that the continents, like huge rafts, floated through the oceans having been situated in different locations throughout the course of the Earth's history.

continental margin- a major division of the ocean basins, this is the zone of separation between the ocean floor and the continent itself.

continental shelf- a section of the continental margin which extends from the shoreline outward until a vertical depth of 600 feet is reached or until the continental slope appears.

continental slope- that part of the continental margin where an abrupt drop-off leading down to the ocean floor becomes apparent.

convergence, areas of- a surface area of converging warmer air which results in a low pressure cell.

convergent plate boundary- a zone where two plates, on a collission course meet with the dominant one overriding the reccessive one. The reccessive plate becomes subducted into the mantle of the Earth with an end result of the creation of volcanoes, trenches, island arcs, and earthquakes.

coral- the external skeleton of the coral polyp made from the extraction of calcium carbonate extracted from sea water. What coral reefs are made of.

coral atoll- an island whose base consists of coral.

coriolus force- all freely moving objects (wind and water) will be deflected or turn to the right (clockwise) in the northern hemisphere and the the left (counterclockwise) in the southern hemisphere downstream from the point of origin due to the rotation of the Earth.

crater- the bowl shaped depression located at the top of volcanoes.

cultural environment- those aspects of one's environment which are man-made and designed to stimulate that thought which is passed down from generation to generation.

current- like a river within an ocean, a movement which takes on a definite direction and is the result of the Earth's rotation.

death rate- to the same group of 1,000 people used in the calculation of the birth rate, the number of deaths which occurred within that group during the course of one year.

decay- the slow decomposition of plant and animal matter.

delta- deposits of silt and sediment located at the mouth of a river.

demography- the scientific study of people in relation to their number.

dense population, areas of- any populated area of the world which has over 250 people per square mile.

deposition- the relocation of transported material which is deposited as a result of the forward movement of the relocator being diminished or a blockage along the path occurring.

distillation- the natural process by which saltwater is transformed into freshwater. Happens at the point of condensation.

distributary- a branch of the mainstream found within the delta.

divergence, areas of- a surface region of settling air spreading outward in a clockwise or counterclockwise fashion depending upon the hemisphere as it flows towards an area of convergence. A high pressure cell.

divergent plate boundary- a zone where two tectonic plates are moving apart in opposite directions. Results in sea floor spreading, rifts, volcanic activity and earthquakes.

drift- the slowest moving of the ocean currents.

dry adiabatic rate- air temperature drops at a rate of 5.5 F for every 1,000 increase in elevation in the presence of air movement and the absence of condensation.

duricrust- a hard brick-like material which is produced when soil formed from the laterization process is exposed to the elements of the atmosphere for an extended period of time. Also called laterite.

earthquake- a sometimes violent, always sudden movement of the Earth's crust along a fault line resulting from the movement of the plates.

ecosystem- a system of the living and non-living sections of an environment and how they inter-relate.

elevation- height above and below the datum plane of sea level.

environment- those aspects of our existance which surround us, influence us, and cause us to adapt.

epicenter- that point located straight up from the focus on the surface of the Earth.

equinox- equal periods of daylight and darkness. Occurs when the sun is at a zenith directly over the equator.

estuary- the submerged mouth of a river which is the result of sea level rising and ocean water inundating the river valley.

evaporation- the natural process by which water in the form of a liquid is transformed directly into a gas due to a temperature change.

evapotranspiration- the combined evaporation from the soil, vegetation, and transpiration. The single most contributor of moisture to the atmosphere over land.

fault- a crack in the Earth's crust along which movement has taken place.

faulted shoreline- one of the major classifications of shorelines created as a result of fault movement.

fertility rate- to a group of 1,000 people, the number of women between the ages of 15 and 45. This range indicates the highest probability of women bearing children.

fiord- a drowned glacial cut valley. As a valley glacier cuts it's way towards the sea, it generally cuts the end of the valley below that of sea level. As the glacier receeds, sea water will inundate the lower end.

flood plain- a depositional feature consisting of sediment which is deposited along the valley of a river during times of floods.

focus- that point within the Earth where earthquakes originate.

Food and Agricultural Organization (FAO)- an organization belonging to the United Nations whose prime objective is to study and assist underdeveloped nations in the development of scientific farming techniques and the production of crops suitable to meet the demands of an ever growing population.

foredeep- another word for trench (see trench)

freezing- the natural process by which water in the form of a liquid is changed directly into that of a solid due to a temperature change.

fringing reef- a coral reef which is attatched directly to the mainland.

frontier- any area of the Earth which is inhabited by 2 or less people per square mile.

gas- any substance which will expand easily to fill any small container.

geometric progression- when anything increases geometrically, the numerical sequence is such that it doubles itself. i.e. 1,2,4,8,16, 32,64.....etc. Thomas Malthus said human reproduction is at a geomentric progression.

gleization- a major soil building process which develops in poorly drained areas such as swamps, bogs, and marshes.

Gondwana- the southern most continent resulting from the break-up of Pangaea. Composed of South America, Africa, India, Australia, and Antatctica.

gorge- a narrow, steep-walled canyon.

Green Revolution- the concept which deals with the development of hybrid seeds which in turn increases the crop yield per acre of basically

grain crops. This diminishes the real possibility of world famine due to the increase of population on a world wide basis.

Gross National Product- (GNP)- the sum total of a nations exports and other economic benefits attributed to it's growth.

groundwater- water which is not evaporated nor runs off into fresh surface waters, but instead is infiltrated into the ground.

growth rate- by calculating the difference between the birth rate and the death rate, you arrive at the growth rate for a group of 1,000 people.

gulley- in progression, the 3rd phase of water erosion as seen in the form of valleys, canyons, gorges, etc.

guyot- sub-marine volcanoes.

headwaters- the point of origin of streams and rivers.

herbivore- an animal which eats only plants.

heterotroph- plants which cannot gain nutrition from the sun, but instead feed off of autotrophs. (i.e. fungi)

hill- any landform which exhibits a relief of 300-1,000 feet.

hot spot- a hole within the mantle through which magma is extruded.

hurricane- a tropical cyclone- a storm which has wind speeds of or in excess of 74 mph.

hydroponic farming- a special type of green house farming where plants are nourished not in soil, but through a base where liquid fertilizers are being constantly fed to the plants. This enables the plants to grow in confined spaces thus producing greater yields.

hygrophyte- a plant which requires large amounts of water to grow.

infant mortality rate- for every 1,000 live births, the number of deaths which occur within that group during the course of one year.

infiltration- when water actually penetrates and enters the ground.

island arcs- a chain of volcanic islands located on a convergent plate boundary next to a trench where two oceanic plates have collided. The chain is usually arc shaped.

Koppen, Dr. Waldimir- scientist responsible for developing a method by which climates of the world could be classified.

Koppen's Climatic Classification- a system by which climates of the Earth are classified according to temperature and precipitation traits.

kwashiorkor- an extreme form of protein deficiency which shows up in new born children. The damage done is permanent. Severe cases of mental and physical retardation is generally the result of the expectant mother not getting a sufficient amount of protein in her diet.

lake- a body of freshwater which is larger in area and depth than a pond and is completely surrounded by land.

landforms- any of the physical features of the Earth.

latent heat of condensation- the small amount of heat released by water upon condensation.

laterite- see duricrust.

laterization- one of the major soil building processes which occurs in the warm and humid regions of the Earth.

Laurasia- the northern most continent which resulted from the break-up of Pangaea. Composed of North America, Europe, and Asia.

lava- molten rock material located on the surface of the Earth.

leaching- the extraction of minerals from the soil as a result of too much heat and precipitation.

life expectancy- the number of years (on the average) a person can expect to live. This varies from country to country depending upon one's physical, biological, and cultural environment.

liquid- (a) any substance which responds to unbalanced forces. (b) molten rock material-as defined inside the Earth.

magma- molten rock material located inside the Earth.

magma reservoir- the collecting point of magma located beneath the surface.

malnutrition- a health problem which occurs when a person does not receive enough protein in their normal daily intake of food.

Malthus, Thomas- the English squire who wrote an essay in 1798 dealing with the realization that world population would soon overtake the production of world food .

Malthusian Theory of Population Growth- with the fact that world population increases at a geometric rate and food production increases strictly artithmetically, in due time the population of the Earth would overtake the available food supply. The problem with overpopulation would eventually be taken care of with the presence of either famine, pestilence, or war.

mantle plume- the magma which wells up through the hot spot in the mantle.

marasmus- a chronic result of undernutrition, this sickness is attributed to a low caloric intake and can affect anyone.

marsh- a wetland in which grass is the main type of vegetation.

meandering- when a river begins to cut laterally across the countryside (sidecutting).

megadeath- a massive amount of deaths occurring to a population over a short period of time.

megalopolis- a term coined by the French geographer Jean Gottman which represents an area very densely populated. Generally this area encompasses several cities where the visible boundary between each one is not well defined.

melting- the natural process by which water in the form of a soild is changed into that of a liquid as a result of a temperature change.

mesophyte- plants which require a moderate amount of water to grow,

mid-oceanic ridge- the third major division of the oceans basins, a 40,000 mile long submerged mountain chain which winds through the Atlantic, Indian, and Pacific Oceans.

Modified Mercalli Intensity Scale- a method of measuring the physical damage caused by an earthquake on a scale of 1-12.

Moho discontinuity- named for the Yugoslavian seismologist, Andrija Mohorovicic, this is the zone of separation between the mantle and the crust.

monsoon- a seasonal reversal of wind caused by the seasonal reversal of pressure cells over areas of large landmasses and oceans.

mountain- any area which exhibits a relief of 2,000 feet or more.

natural succession- the orderly transferal of one plant community to another.

negative growth rate- attained when the death rate of a country exceeds the birth rate.

neutral shoreline- a major classification of shorelines in which new materials are added to the existing shoreline extending it further out into the sea.

normal lapse rate- under calm conditions, air temperature drops at a rate of 3.5 F for every 1,000 foot increase in altitude.

nuee ardente- a cloud of superheated steam and ash which is extruded from a volcano during an eruption (also called a Pelean cloud)

oblate ellipsoid- the true shape of the Earth. Somewhat flatted at the poles and buldging at the equator.

ocean- the largest of the Earth's bodies of water of which there are 5: Pacific, Atlantic, Indian, Arctic, and Southern.

omnivore- animals which eat both meat and plants.

overpopulation- any area which cannot physically support the number of inhabitants living within it.

Pacific Ring of Fire- see circum- Pacific belt.

Pangaea- the name of the super continent which existed some 200 million years ago when all of the Earth's continents were joined.

Panthalassa- The name of the body of water which surrounded Pangaea. The ancestoral Pacific Ocean. (see Pangaea)

Per Capita Gross National Product- the average amount of money attributed to each person in a country per year.

perihelion- the closest position the Earth is to the sun in it's orbit. Occurs January 3 at a distance of 91.5 million miles.

photosynthesis- the ability of certain plants to convert sunlight into food energy.

physical environment- those aspects of one's environment which are inorganic, non-living, or never having lived.

plain- any physical feature of the Earth which exhibits a relief of 0-300 feet.

plates- huge sections of the Earth's crust which are moving very slowly in various directions.

Plate Tectonics- the theory which states that the crust of the Earth is fractured into huge sections called plates. Through convectional currents from the mantle, these sections move very slowly in various directions. Responsible for the development of volcanoes and earthquakes in particular.

plateau- an elevated flatland which is higher on at least one side than the area surrounding it.

podzolization- one of the major soil developing processes which occurs in the cool and humid regions of the world.

polyp- the microscopic animal of the sea which is responsible for the development of coral.

pond- a small body of frshwater, shallow enough to allow sunlight to penetrate and strike the bottom thus stimulating plant growth throughout. Completely surrounded by land and smaller in both area and depth than a lake.

population density- the average number of people per square mile or kilometer living in a particular area.

positive growth rate- attained when the birth rate of a country exceeds the death rate.

precipitation- moisture from the atmosphere which falls in the form of rain, sleet, hail, or snow.

predominant economic activity- the major economic endeavor the country in question is engaged in.

protein- consisting of the 20 amino acids found within certain foods, protein is absolutely essential in maintaining a healthy existence.

ravine- a small canyon.

relief- the difference in distance between the highest and lowest points in elevation.

Richter, Dr. Charles- developed the scale most seismologists use to measure the movement of the Earth during an earthquake.

Richter Scale- measures the intensity of earthquakes on a scale of 1-10. Each whole number identifies an intensity which is 10 times greater than the number before it.

rift- a splitting of the Earth on one of it's landmasses which forms along divergent plate boundaries. (i.e. the Great Rift Valley of eastern Africa)

rill- the second stage of water erosion

river- a body of freshwater which flows through the countryside and empties into another stream or larger body of water.

rot- the rapid decomposition of plant and animal matter.

rotation- the spinning of the Earth around it's axis.

salinization- a major soil developing process which occurs in the poorly drained desert regions of the Earth.

saltwater intrusion- along the coastal regions where the supply of fresh groundwater is depleted below that of sea level, saltwater seeps inland replacing it causing much distress to the plant life of the area.

sea floor spreading- an opening of the Earth along divergent plate boundaries on the floor of the ocean. The counterpart of a rift.

sea level- the plane measured at 0 feet elevation.

seismograph- the instrument used to measure the intensity of earthquakes.

seismology- the science dealing with earthquakes.

sheet- the initial stage of water erosion.

shoreline of emergence- a major classification of shorelines where there is a rising of the Earth's crust near the border of a continent, or a lowering of the sea level.

shoreline of submergence- a major classification of shorelines where there is a sinking of the Earth's crust near the border of a continent, or a rise in sea level.

slope- the slant, steepness, or configuration of landforms

solid- (a) any substance which resistance change in regard to shape and size.
(b) within the Earth- changes in consistency due to heat and pressure:
crystalline- inner core
elastic quality in regard to being shaped- mantle
brittle- crust

solstice- (a) literally, when the sun appears to stand still
(b) the farthest points north and south of the equator the sun shines directly overhead

source region- those certain stable regions of the Earth over which air masses develop.

sparse population, areas of- any area of the Earth whose population density is 25 people per square mile or less.

stream- any body of water which flow through the countryside.

subduction- the act of being drawn beneath- when a dominant tectonic plate overrides a reccessive one forcing it beneath eventually to be absorbed into the mantle.

sublimation- (a) the natural process by which water in the form of a gas is changed directly into that of a solid.
(b) the natural process by which water in the form of a solid is changed directly into that of a gas.

swamp- a wetland in which trees are the main type of vegetation. (bald cyprus and mangrovee)

terrestrial radiation- the releasing of heat from the Earth as absorbed by the sun. Those high frequency wave lengths of radiation which are absorbed by the Earth, changed into low frequency wave lengths of radiation, and released back out into space.

Tethys Seaway- the east-west body of water created when the super continent of Pangaea separated. The present day location of the major deposits of oil in the world.

tides- one of the major movements of the oceans caused by either the gravitational pull of the moon or the centrifugal force of the Earth's rotation. The alternate rising and falling of the surface of the ocean.

transform fault boundary- a plate boundary in which 2 tectonic plates are literally slideing past one another.

transpiration- when a plant actually releases water in the form of a liquid.

transportation- the re-location of the Earth's eroded or weathered materials by the forces of nature.

trench- a deep chasm on the ocean floor that is actually the boundary between 2 convergent plates. As 2 oceanic plates, or 1 oceanic and 1 continental plate collide, the zone of subduction on the ocean floor becomes the trench.

tributary- a stream or river which flows into another stream or river. Contributes water to the mainstream.

trophic pyramid- a food chain beginning with the sun and consisting of autotrophic and heterotrophic plants, along with herbivorous, carnivorous, and omnivorous animals.

tropical cyclone- an intense area of low pressure which produces a rotary circulation of air in excess of 74 mph. Also called a hurricane, cyclone, typhoon, and wooly wooly.

tropical depression- a storm which produces a rotary circulation of air at the surface with a steady and consistant wind speed of 38mph. The second phase in the development of a hurricane.

tropical disturbance- a weak interruption in the overall pattern of wind and air pressure which creates a moving area of thunderstorms which maintains it's identity for a period of 24 hours or more. The initial phase of a hurricane.

tropical storm- as the 3rd phase in the development of a hurricane, the rotary circulation of air at the surface during this phase exhibits a wind speed ranging from 39-73 mph.

turbidity streams- vertical gulleys cut into the continental slope as a result of mudflows from the continental shelf. These mudflows are created by earthquakes, volcanic eruptions, or severe storms.

undernourishment- a person is said to be undernourished when he or she does not receive enough calories in their food intake during the course of a day over an extended period of time.

urban growth rate- calculated the same as any growth rate, this deals strictly with the increase of the urban centers of the world.

valley- any area which is drained by it's rivers and tributaries.

vegetation- the total array of plant life.

vent- the opening of the conduit through which magma is extruded into the crater.

volcanic kneck- hard spirals of rock extruding from what was once the crater of a volcano.

volcano- individual mountains generally located along plate boundaries built by volcanic debris extruded from the Earth.

wave- the "rythmic" up-down movement of the surface of the sea.

weather- the daily conditions of the atmosphere.

weathering- a destructive force of nature affecting landforms over a period of time. With no physical movement, the agents of air, gravity, frost action, salt crystallization, and tree roots aid in the breaking down of the Earth's landforms.

Wegener, Alfred- the German scientist who 1st proposed the "Continental Drift Theory".

wet adiabatic rate- in the presence of wind and condensation, air temperature drops at a rate of 3.2 F for every 1,000 foot increase in elevation.

world growth rate- the difference between the world's average birth and death rate.

World Health Organization (WHO)- an organization belong to the United Nations whose prime objective is to aid those nations in need of medical assistance but cannot afford such assistance themselves.

xerophyte- plants which require very little water to grow.

yazoo stream- when a natural levee blocks the entrance of a tributary from entering the mainstream, the tributary follows the levee until an opening occurs at which time it can enter. This special type of tributary stream is called a yazoo stream.

zenith- that point at which the sun is shining directly overhead (90 above the horizon) Occurs between the tropics only.

Zero Population Growth- the figure attained over the long run when the birth and death rates are equal.

INDEX

abraission 91
abyssal plain 62
active layer 121, 122
active volcano 68
adaptation 106, 168
aerobic bacteria 112
air mass 62, 109, 168
Alaskan Earthquake 77
alluvial fan 95, 168
alpine meadow 121
alpine tundra 121
altitude 29, 109, 168
anthracite 56
aphelion 9, 168
aquaculture 160, 168
aquafer 130, 131
arctic tundra 121
arete 80
arithmetic progression 146, 168
Article #24, Law of the Sea 100
atmosphere 50
autotroph 116, 168
autumnal equinox 10
axis 3, 168

badlands 132, 168
base level 138, 168
base minerals 110, 148, 168
barrier reef, 97, 168
beaver pond 140
biochore 105, 168
biocycle 105, 168
biological environment 104, 168
biologist 122
biome 105, 168
biosphere 104, 168
birth rate 150, 168
bituminous coal 56
bog 107, 140 169
boreal forest 117
Borlaug, Dr. Norman 159, 169
botanist 122
brackish 141, 169
broadleaf evergreen tree 122
broadleaf tree 122

calcification 112, 169
calcium carbonate 129
caldera 70, 169
canopy 111
canyon 64, 169
caprock 130, 131
carbonic acid 129
carnivore 116, 169
caverns 129
caves 129
census 169
center of gravity 51
centrifugal force 7, 169
chinook winds 25
cinder cone 69
circle of illumination 10, 169
circum- Pacific belt 69, 169
cirque 79
climate 12, 108, 169
climax community 107, 169
climax vegetation 169
coastal needleleaf evergreen forest 118
col 80
composite cone 69
compound shoreline 97, 169
condensation 125, 127, 128, 169
conduit 143, 169
cone of depression 143, 169
coniferous 117, 122
confluence 133, 136, 169
contiguous zone 101
Continental Drift 55, 170
continental glaciation 80
continental margin 61, 98, 170
continental shelf 61, 99, 170
continental slope 61, 99, 170
convection currents 60
convergence, areas of 18, 19, 170
convergent plate boundary 59, 170
coral 96, 170
coral atoll 97, 170
coral reef 96
coriolus force 8, 170
crater 7, 170
crust 52, 54
cultural environment 105, 170
current 87, 170
cyclone 35
cyprus pond 139

datum plane 48
death rate 150, 170
decay 110, 170
deciduous 122
decomposer 122
deep focus 73

delta 94, 136, 137, 170
demography 146, 170
dense population, areas of 147, 171
deposition 132, 171
dew point 115
distillation 124, 171
distributary 136, 137, 171
divergence, areas of 18, 19, 171
divergent plate boundary 58, 171
dormant volcano 68
drift 88, 171
drumlin 81
dry adiabatic rate 29, 171
dry desert, 120
duricrust 111, 171

early maturity 138
early youth 137
earthquake 72, 171
ecliptic, plane of 3
ecologist 122
ecology 122
ecosystem 116, 122, 171
electromagnetic spectrum 12
elevation 29, 48, 171
environment 104, 171
epicenter 72, 171
epiphyte 122
equatorial doldrums 20
equilibrium 138
equinox 9, 171
Eratosthanese 4
esker 81
estuary 94, 171
evaporation 125, 127, 171
evapotranspiration 128, 172
evergreen tree 122
extinct volcano 69

farm pond 40
fault 76, 172
faulting 63
faulted shoreline 97, 172
fertility rate 151, 172
fiord 80, 93, 172
firn 79
floodplain 138, 172
focus 72, 172
foehn winds 25
folded mountains 63
Food and Agricultural Organization 154, 172
forbs 119
foredeep 62, 172
fossil waters 130
freezing 125, 126, 172
fringing reef 96
frontier 148, 172
fumarole 130, 131

gas 125, 172
Geneva Convention 100
geocentric theory 6
geomorphologist 48
geomorphology 48
geometric progression 147, 172
geothermal 130
geyser 130, 131
glacial eratic 81
glacial step 80
glacial trough 79
glacier 79
gleization 112, 172
gley 112
Gondwana 57, 172
gorge 64, 172
green plant stage 55
Green Revolution 159, 172
Gross National Product 152, 173
groundwater 173
growing season 149
growth rate 150, 173
gulley 132, 173
guyot 62, 68

hammock 122, 142
hanging valley 80
headwaters 136, 173
heliocentric theory 6
herbivore 116, 173
heterotroph 116, 173
high seas 101
hill 49, 173
horn 80
horse latitudes 20
hot spot 68, 173
hot springs 130, 131
hurricane 35, 173
hydroponic farming 160, 173
hygrophyte 173

ice berg 81
ice marginal lake 81
impermeable 130
infant mortality rate 151, 173

infiltration 129, 173
inner core 52, 54
interlobate moraine 81
intermediate zone 73
internal waters 101
island arcs 59, 62, 173

jungle 114

kame 81
karst 140
katabatic winds 25
kettle pond 81, 139
Koppen, Dr. Waldimir 36, 173
Koppen's Climatic Classification 36-40, 173
kwashiorkor 53, 174

lagoon 97
lake 174
lake forest 118
land breeze 24
landforms 48, 174
late maturity 138
latent heat of condensation 29, 174
late youth 138
lateral moraine 80
laterite 111, 174
laterization 111, 174
latitude 12, 108, 148, 149
Laurasia 57, 174
lava 65, 174
lava dome 69
leeching 111, 174
levee 136
liana 122
lichens 122
life expectancy 157, 174
lignite 55
liquid 51, 125, 174
literacy rate 151
low angle overthrust fault 76

magma 65, 130, 131, 174
magma reservoir 71, 174
mainstream 136
malnutrition 153, 174
Malthus, Thomas 147, 174
Malthusian Theory of Population Growth 147
mantle 52, 54
mantle plume 69, 174
marasmus 154, 174
marsh 107, 140, 175
medial moraine 80

megadeath 154, 175
megalopolis 153, 175
melting 125, 126, 175
mesophyte 119, 175
mid-latitude deciduous forest 117
Mid-Oceanic Ridge 117, 175
minor landforms 64
mixed forest 122
Modified Mercalli Intensity Forest 75, 76, 175

Moho discontinuity 53, 175
Mohorovicic, Andrija 53
momentum 150
monsoon 23, 175
monsoon forest 114
moraine 80, 81
mountain 63, 175
mountain breeze 25

natural succession 106, 175
needleleaf forest 117, 122
needleleaf evergreen forest 118
negative growth rate 150, 175
neutral shoreline 94, 175
New Madrid Fault 77
normal fault 76
normal lapse rate 27, 28, 175
nuee ardente 66, 175

oblate ellipsoid 3, 175
oceans 83, 175
ocean currents 109
ocean floor 62, 99
omnivore 116, 175
orographic precipitation 115, 122
outer core 52, 54
outwash plain 81
overpopulation 145, 175
ox-bow 138
ox-bow pond 139

Pacific Ring of Fire 19, 176
pampas 122
Pangaea 57, 176
Panthalassa 57, 176
peat 55, 112
Pelean Cloud 66
Per Capita Gross National Product 152, 176
perihelion 9, 176
permafrost 122
permeable 130
photosynthesis 116, 122, 176
physical environment 104, 176

piedmont glacier 81
pillow lava 62
plains 49,64, 148, 176
plate boundaries 58
plates 57, 176
plate tectonics 57, 176
plateaus 64, 176
podzolization 111, 176
Polar Easterlies 21
Polar High Pressure Belt 21
polyp 96, 176
pond 107, 139, 176
population density 147, 176
porosity 130
positive growth rate 150, 176
prairie 119, 122
precipitation 128, 176
predominant economic activity 177
Prevailing Easterlies 21
primary treatment 156
primary waves 51
protein 153, 177
pure stand 122

ravine 64, 177
recessional moraine 80, 81
relief 49, 177
reverse fault 76
revolution 8,9
ria shoreline 93
Richter, Dr. Charles 73, 177
Richter Magnitude Scale 73, 177
rift 58, 177
rill 132, 177
river 133, 177
rot 110, 177
rotation 6, 177

salinization 112, 177
saltmarsh 140
saltwater intrusion 143, 177
San Andreas Fault 77
San Frabsisco Earthquake 77
Santa Ana Winds 25
saturation point 115
savanna 119, 122
sclerophyll forest 118
sea arch 92
sea breeze 24
sea cave 92
sea floor spreading 58, 84, 177
sea level 177
sea stack 92
secondary treatment 156
secondary waves 51
seismograph 73, 74, 177
seismology 73, 177
semi desert 120
shallow zone 73
sheet 132, 177
shield 63
shield volcano 69
shoreline of emergence 94, 177
shoreline of submergence 93, 177
sinkholes 129
sirocco winds 25
slope 49,178
solid 51, 125, 178
solstice 9, 178
SONAR 98
source region 32, 178
southern pine forest 118
sparse population, areas of 148, 178
Standard Metropolitan Statistical Area 148
stellar parallax 10
steppe 119, 122
strato volcano 69
stream 178
storms 34, 110
subduction 59, 178
sublimation 125, 126, 178
Sub-tropical High Pressure Belt 20, 120
Sub-polar Lows 21
summer solstice 10
surface waves 51
swamp 107, 140, 178

taiga 118
tarn 79
temperate rainforest 115
terminal moraine 80, 81
terrestrial radiation 23, 178
territorial seas 101
tertiary treatment 156
Tethy's Seaway 57, 178
tides 87, 178
till plain 81
timberline 122
topography 109
trade winds 20

traditional values 157
transcurrent fault 76
transform fault 76
transform fault boundary 58, 178
transpiration 128, 178
transportation 132, 178
trench 59, 62, 178
tributary 136, 179
trophic pyramid 116, 122, 179
tropical cyclone 34, 179
tropical depression 35, 179
tropical disturbance 34, 179
tropical rainforest 113
tropical storm 35, 179
trough lake 80
truncated spur 80
tundra 120, 122
turbidity stream 61, 179
typhoon 35

undernourishment 154, 179
urban growth rate 152, 179

valley 64, 179
valley breeze 24
varves 107
vegetation 122, 179
vent 71
vernal equinox 10
volcanic ash 65
volcanic bomb 65
volcanic cinder 65
volcanic dust 65
volcanic neck 70, 179
volcanic shoreline 95
volcano 64, 65, 179

wave 87, 179
weather 12, 179
weathering 91, 179
Wegener, Alfred 55, 180
wet adiabatic rate 29, 180
windward 115
winter solstice 10
wooly-wooly 35
world growth rate 180
World Health Organization 157, 180

xerophyte 120, 180

yazoo stream 136, 180

zenith 4, 180
zero population growth 150, 180
zone of diffussion 101

FOOTNOTES

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